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THE RELATION OF CLASS TO LABORATORY WORK IN BIOLOGICAL TEACHING.[1]

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In the old city of Nüruberg, in Germany, there is a very famous carving known as the "Nüruberger Trichter," which represents a schoolmaster holding a funnel to an opening in the top of the head of a luckless school boy, into which he is supposed to be pouring knowledge.

The funnel method of teaching has long been very popular. It exalts the importance and lends to the prominence of the schoolmaster. I dare say that in spite of all our advance in education, so far as materials are concerned, one great and glaring defect of which our present day education is still guilty, consists in our acting as though education were a process of imparting information by an active agent called the teacher, to a passive agent called the student.

No educator who has read the famous book of Dr. Maria Montessori[2] (and no educator should be able to plead guilty of not having read it)—can fail to realize the difference between the fundamental principle of educational method as propounded by Dr. Montessori, and the general current method obtaining in our schools and colleges. According to Dr. Montessori's idea, the teacher instead of the pupil should be utterly passive and in the background. The activity and the initiative are to be left to the pupil. In other words, education from this point of view, is an individual problem of self development on the part of the pupil to be worked out by himself alone, the sole function of the teacher being to guide the released energies into productive channels.

I take it that this is the only scientific point of view of education as a method, and that any method or system that exaggerates the teacher and places him in the foreground, or which renders his activities the conspicuous and evident feature of the educational

[1] Read before the General Science Division of the Faculty of the Kansas State Agricultural College, session of Jan. 13, 1914.

[2] *The Montessori Method*, by Maria Montessori, pub. Fred. A. Stokes Co., N. Y.

process, is wrong and unscientific. Fundamentally it would seem that the main purpose of education is not so much to convey already existing information, as to invite individual initiative, to develop individual will and judgment, to train the individual senses and to make the child into a creative instead of an imitative being.

I think I may say without contradiction, that, for the most part, our public school and college system of so-called "education" does as yet very little in the way of training the special senses, does very little to develop the power of reasoning, and of forming independent judgments from new data, and almost utterly neglects the training of the will. The most that is generally done, is to train the children to store up a mass of memorized data of one consecrated sort or another. Of course I make this as a general statement. There is incidentally some training of the senses, some training of the reason and some training of the will, but it is not done consciously, intentionally, or intelligently for the most part. The natural result is that the ordinary school product has had most of the originality and initiative ironed out of him, and, in his most perfect form, more nearly resembles a phonographic record than anything else.

This public school product comes to us to be operated upon in an educational way by whatever instruments or methods we may possess. Those of us who are working in the natural sciences, find for the most part, that he is unable to use his hands in drawing, that there is little or no coördination between the eye and the hand, that he is as a rule unable to see into objects and observe them independently, and that he is very little capable of drawing conclusions from what he has seen. He is a creature almost entirely dependent upon blackboard or typewritten outlines, without the aid of which he dare not venture into the unknown in science. He is a slave to the text-book and the teacher—to the written word and the printed page, and above all, he has been trained to act largely as a silent and passive instrument, into which the substance of something which is called an "education" is to be poured as through the Nüremberg funnel.

From what has just been said, it may be inferred that there are certain features of our educational system with which the writer is not absolutely contented and satisfied. So far as the relation between class work and laboratory work in the natural sciences is concerned, I shall have to begin by saying that I do not believe in class work at all.

I do not believe in the formal recitation as an educational method, at least as it is ordinarily handled, and as it must be handled in most cases. The theory is of course, that the subject matter under discussion is to be brought out by the student as the active agent, and that the teacher, if he is a skilful and experienced one, plays a minor part in the process, merely leading the student out into the expression of his own mind. I am aware that such may be the case, and I am going to endeavor to present a suggestion as to how it may be made more generally the case than it is at present. As to the lecture method, whatever its value in university work, I am sure that I am not very far from the facts in saying that, as a means of teaching biology to average college freshmen, it is, in the estimation of most competent educators of long experience, utterly out of place.

As a teacher of one of the biological sciences, in which, in its elementary stages, the work is largely observational, it is my feeling that the best results can only be obtained by having a maximum amount of observation carried on by the student himself. As at present organized in our college, with say, two hours for class work and four hours for laboratory work in the week, there is not, in my estimation, a sufficient amount of time given to the actual work of observation to enable a student either to observe long or closely enough, to absorb, or to turn over in his mind and mentally digest the things that he does observe. In my own experience, and I think in the experience of most biology teachers, the laboratory time is all too short, and the sensation throughout on the part of the instructor, is one of haste and hurry to cover the ground, and to cram somehow or other into the limited time at his disposal, enough observational work to give the student, in some sort of a fashion, a comprehensive survey of the subject matter of the science. The result naturally is, that the laboratory process, from the student's standpoint, amounts to a rapid pouncing upon a swiftly appearing and disappearing series of natural (or unnatural) objects. I note that the habitual mental attitude of the student who has finished his work upon one plant or animal form, is not the further contemplation of that form with a view to comprehending it more perfectly, and of placing it in its relations to other plant or animal forms previously studied. His mind is cast ever yearningly toward the future, toward the next thing that is to be gotten rid of by dint of drawing it. His attitude of mind may best be expressed by the current question familiar to all teachers in elementary biological laboratories, "What are we supposed to draw next?"

It would seem from the above indictment that the present writer, having already condemned the recitation and lecture methods as conducted at present in elementary biological courses, is now amusing himself by condemning the laboratory method. Such, however, is not the intention. It is my present feeling that the laboratory method, or some modification of it, is inevitably the correct method for the study of the sciences, but in order for the laboratory method to be really effective, it must be extended enough in point of time, to allow for deliberate thought upon, and a detailed study of, the living forms. If I were allowed to do my own experimenting in the matter, regardless of schedules, and of the number of students waiting to be stuffed through the door of my particular laboratory, I think I should enjoy experimenting somewhat as follows:

I would wholly abolish the recitation as a formal exercise. I should have all of the work done in the laboratory, which would be equipped with stereopticon and projectoscope, blackboards and charts, aquaria, and a small conservatory or greenhouse opening immediately out of it on the same floor. I would have four laboratory periods a week instead of two, and during these periods, with not to exceed twenty students in the section, I would undertake to make the laboratory work as far as possible become a personal development in observation by each individual student. I should take more time for the study of each form of life considered, and should endeavor to get at the subject from more angles. I should feel free to vary the work at any time by the use of the stereopticon or charts or blackboard, in order to illustrate special phases, or by conference to develop or summarize the results of the observations. I would have the students turn from the laboratory work to a conference, whenever, in the logical development of their observations, I thought it would be proper for them to form conclusions. These conferences, informal in character, and not occurring at definite, stated intervals, would take the place of "recitations," and would serve as a recitation ordinarily does not serve, to summarize the results of a series of observations. In this way I should be absolutely certain of just the kind of conclusions, inferences and impressions the students were getting at every stage of the work, and when an incorrect impression or observation turned up, the student could instantly be referred back to the object or the microscope to correct it then and there. Time and again, I have tested the value of these laboratory conferences, and I feel that they are absolutely indis-

pensable, but the limited time at our disposal at present does not enable us to make the extended use of them that we should like.

I should, of course, require reading to be done. Perhaps if there were a suitable one, I should have a text-book as a general guide. At all events, I should require a great deal of topical collateral reading, and should have special conferences, seminars, or whatever you may please to call them, in which a summary of these required readings would be given. At intervals not stated or prescribed, I should of course have oral or written quizzes.

This is, more or less, a rough sketch of my idea of conducting an elementary course in one of the biological sciences. I would eliminate the formalism and rigidity of the set recitation, with its passive student and active teacher, and would endeavor to substitute for it a group of active young investigators thrown largely at the mercy of their own resources in a laboratory. I am not certain that I should even use "outlines." I fear that in most laboratory work in such courses, the student first looks at the outline with its numbered and lettered sub-heads and then at the subject, to see if he can find there the things set forth in the outline. The outline, and not the plant or the animal, is thereby made the responsible party, and if a, b, c, or d does not occur in the object, so much the worse for the object. Laboratory work done in this fashion, becomes about as grotesque a simulation of scientific work as can be imagined—less fruitful than looking up words in a dictionary; as much so as pasting postage stamps in an album.

Now since we cannot have eight hours a week, with no recitations, and with not to exceed twenty students, and with the equipment and conditions suggested, it becomes a problem of what we are going to do with our two hours of class and four hours of laboratory work per week, as it stands. I should say that in my judgment, the best way of mitigating the worst evils of the present system, is to ensure first, that every student be enabled to have his class work and laboratory work under the same instructor. If this be impossible, then it becomes the duty of the head of the department to keep the laboratory work, as conducted by the various instructors, enough in advance of the work in the text or lectures, so that the class work becomes virtually a review conference of what has actually been seen by the student in the last one or two laboratory periods. I cannot conceive of anything more futile or absurd, than for a class in botany or zoölogy to be engaged in the silly parrotry of "reciting" out of

a text, memorized information about plants or animals that they have hitherto never seen. The biological sciences, and the sciences in general, have suffered long enough from the evil of being compelled to follow the stereotyped methods of class instruction followed in mathematics and the languages, in logic and philosophy. It must be remembered that in the sciences, what we are after is observation and experiment, not formal memorization of facts or practice in dialectics.

I would summarize therefore, by saying that if class work is to be maintained in elementary science courses, it should consist largely, and, I think in the biological sciences, wholly, of conferences to review the laboratory work previously done, with the addition of special reports on assigned topics, designed to broaden the student's grasp of the kind of material he is working with.

Above all, I would emphasize, that in the class work, if we have to have it, every device be considered and brought into play, which will break up the prevalent mass-effect that we now too often witness—of a phalanx of passive students, solidly and stolidly defending themselves against, or else with more or less agility evading, a bombardment of questions by an over-zealous teacher.

TILLOTSON WHEELER GILSON.

Text-book publishing loses another of its best-known leaders and thousands of teachers lose a personal friend by the death of T. W. Gilson, at his home in Winchester, Massachusetts, on April 23rd.

Tillotson Wheeler Gilson was born at Hartland, Vermont, August 6, 1849. He fitted for college at Kimball Union Academy, Meriden, New Hampshire, and was graduated from Dartmouth in 1874. After some experience in teaching, he became associated with D. Appleton and Company, finding what was to be his life work—educational publishing. He soon transferred his connection to the J. B. Lippincott Company, and later went to Philadelphia as manager of the educational department. Here he remained for some ten years, and his experience covered editorial as well as agency work.

He joined Ginn and Company as a member of the firm in 1892. His great work for this company was done as manager of the common school department of the Chicago office. In 1906 he removed to Boston to take charge of the New England sales department of Ginn and Company. A serious illness about the time of his transfer left its imprint on his constitution, and some two years ago he was relieved from his duties in the active management of the business. Since that time he has been associated with the editorial department of Ginn and Company. For this editorial work he had unusual natural qualifications which, supplemented by his long and varied experience, made his advice and judgment of the greatest value.

WORDSWORTH'S MESSAGE TO MODERN EDUCATORS.

By Jean Broadhurst,
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Asphalted now are all of Lucy's "untrodden ways" and over them chugs the tourist glimpsing the chimney of Dove Cottage but missing entirely the "violet beside the stone," the open sesame to the whole lake region, its poetry, and to Wordsworth himself. Not a few of the people pedagogically interested and occupied dilate upon the deeper meanings of Wordsworth's "Intimations of Immortality"; but pursuing this more obvious road, never pause at his simple little tale, "An Anecdote for Fathers."

Written about a century ago it preceded by not a few years the rage for the statistical study of intellectual processes. Had Wordsworth called it an anecdote for teachers, or supervising principals, or for eminent psychologists, it might possibly have received the recognition due it, and so have saved hours of useless labor and misdirected effort.

This poem of fifteen stanzas describes a father walking with his five-year-old son at Liswyn farm. His thoughts chance to revert to "Kilve by the green sea," his "home when Spring began, a long, long year before," and so, presumably, not very vividly within the child's power of recall. The following stanzas tell the story.

* * * * * * * * * * * * *

"And, as we talked, I questioned him,
In very idleness.

" 'Now tell me, had you rather be,'
I said, and took him by the arm,
'On Kilve's smooth shore, by the green sea,
Or here at Liswyn farm?'

"In careless mood he looked at me,
While still I held him by the arm,
And said, 'At Kilve I'd rather be
Than here at Liswyn farm.'

" 'Now, little Edward, say why so:
My little Edward, tell me why.'—
'I cannot tell, I do not know.'—
'Why, this is strange,' said I;

" 'For here are woods, hills smooth and warm:
There surely must some reason be
Why you would change sweet Liswyn farm
For Kilve by the green sea.'

"At this my boy hung down his head,
He blushed with shame, nor made reply;
And three times to the child I said,
'Why, Edward, tell me why?'

"His head he raised—there was in sight,
It caught his eye, he saw it plain—
Upon the house-top, glittering bright,
A broad and gilded vane.

"Then did the boy his tongue unlock,
And eased his mind with this reply:
'At Kilve there was no weather-cock;
And that's the reason why.'

"Oh dearest, dearest boy! my heart
For better lore would seldom yearn,
Could I but teach the hundredth part
Of what from thee I learn."

Today enthusiasts spend much time collecting material supposed to show the inner workings of the child mind. And upon these interpretations depend the literature taught, the selection of school music, much of the art work, and even the methods of class management, moral training, and intellectual discipline.

A contrary-minded child balks and the over-conscientious teacher questions if her methods are not to blame. A questionnaire is prepared, whole classes are quizzed, and a contribution is made to child psychology! And we learn such things as "Girls prefer blue (or is it red?) while boys prefer red." Pressed for reasons, we find that red is cheerful and warm, that blue is like flowers and the sky. And the art course is properly modified; the color scheme of the class room is changed. For we fail to realize that the poor things had to say something; that red, or blue, or green are but Liswyn farm and Kilve by the green sea. It needs but a chance weathercock to supply a real reason for the selection.

There are several things that doubtless influenced the conclusions regarding color which were more or less misstated above. A few questions will indicate these: *First*: How many colors, with correct names, did the children know? *Second*: Were the other possible choices in color as easy for the child to spell as the popular red or blue? A man once went to Newport instead of Narragansett because it was necessary to write his fiancée to meet him at the place selected, and he *could* spell Newport. *Third*: Or, even if the answers were given orally, how much did the teacher's own choice or that of other children affect the results? Once while teaching in a school where the classes voted for an arbor day tree, I was pleased to have my favorite tulip tree (*Liriodendron Tulipifera*) carry the day. The very name tulip tree should have made me realize my unconscious influence, for the few people in that locality who knew the tree at all called it "white poplar." *Fourth*: How much did associations or reasons wholly foreign to the single color and its simple emotional effect influence the choice? Did the teacher wear a red tie? Had the mothers found red the most becoming color for those little Italian or Jewish children? Or blue the most serviceable for wash dresses and waists? What color did the clown wear in last night's picture show? *Fifth*: Did they really know? I put it to you. Which color do you prefer? Well, green for trees and grass, and blue for sky and gentians, and red for apples and—. Exactly. Pure, unadulterated, unattached color means little to most of us. Once or twice a year when using carmine particles to demonstrate Brownian movement I open the bottle and look long and full into its red, red depths, and think that color has never so appealed to me before. But that carmine bottle always stays upon the closet shelf until the next term! If we can not decide the matter abstractly, what right have we to take a child's forced selection to be an expression of a complete abstraction, based upon pure color without any of its associated and influencing accompaniments. *Sixth*: If he does know, does he care to tell? Why do you prefer lilac? Because it is very becoming to you, and so few women can wear it. But you say it is because it is such a delicate color. Or it may be because of that May meeting beside the lilacs. But, you protest, you couldn't be expected to blurt right out that John first kissed you beneath the lilac bush; of course not. But you had to say something and so you lied. Who wouldn't? Even a child might. I omitted, you may have noticed, Wordworth's sub-title to the poem just quoted, "Showing How the Practice of Lying May be Taught."

In that charming book, *The Romance of a Nursery,* L. Allan Harker has shown the same thing. As I recall the incident, a child-study person and a note book (or shall we reverse the order?), came to the nursery wishing to interview the precocious, book-devouring Paul. Paul, aged seven, still retained some of his baby mis-pronunciations, and his serious manner completely deceived the investigator. To the question, "Who is your favorite character in history?" he answered, "Henry ve Eighth." With a gasp, the interrogator jotted that down, and then asked "Why?" "Because," said Paul, reflectively, "I've noticed vat most men have more children van wives. But Henry ve Eighth had more wives van children." As the door closed, an older brother took Paul to task for the statement recorded, but Paul justified himself and dismissed the subject by saying contemptuously, "Do you suppose I was going to tell her what I think?"

Children are no fonder of baring their naked little souls than are grown people. That is, of course, normal children, and normal grown people. A normal boy or girl plows right ahead, without any of that internal analysis. And normal adults avoid it, usually. But there are no depths or lengths to which the abnormal will not go. Before an interested or even passive listener they may absolutely insist on an old-time housecleaning of the inner temple, and beat upon the clothes line the altar cloths from their "holy of holies."

I have often wondered that normal women have not made a joint protest against some of the qualities attributed to them in one of the chapters of Stanley Hall's "Youth." Morbid or neurotic contributors must have predominated. The only other explanation is the *single* experiences stood out too prominently and influenced unduly the answers upon which the conclusions were based. Even a fortune-teller or palm reader counts upon the unbalanced effect of single experiences, knowing that any adjective he may apply will be readily received as descriptive. A quick-tempered person will, of course, admit the fact; but it is also true that even the mildest of worms will accept the same term as characteristic, remembering most distinctly the one time he *almost* turned.

Children's statements are today used in revamping courses of study. Not only are single topics added, abbreviated, or dropped, but a curriculum may lose or gain a whole subject, such as Latin, zoölogy, physiology, manual training, and music. The data leading to these adverse or favorable decisions are usually as unfair

as those cited in reference to color. For instance, at the end of a first year science course consisting of elementary zoölogy, elementary botany, and human physiology, the children were asked to write down the topics that interested them most. Botany and zoölogy, which were completed during the first two-thirds of the year, received very few votes; most of the class mentioned physiological topics as their favorite ones. Many of these were selected from the last two or three weeks of the course given over to the discussion of bacteria and their relation to life. These results were discussed at an important high school conference, and interpreted to mean that the children were much more interested in a knowledge of their own bodies than in the study of plants or animals; that their real and vital interests lay in the practical phases of health, sanitation, etc. All of which is perfectly possible, but cannot be considered proven unless the same votes are obtained under other conditions: (1) with botany and zoölogy in their turn the last subjects studied; or (2) when all three are so far in the past that the last studied has but a trifling advantage. To give the child a whole year of sanitation and no botany or zoölogy might be the last thing he would really like. And I see no reason to believe that any such modification of any course or courses would be any nearer the child's needs than one planned in cold blood by a logical teacher, who remembered something of his own scientific training and saw the course as a related whole.

There is a valuable work to be done by questionnaires even with children. But a little more care must be taken to be certain that we know exactly what the results *do* show. They *may* picture the child mind even to the last association process. But it is equally possible that they may be but monuments to our own stupidity and gullibility. Under such conditions the child may gain in imagination and inventiveness, but to the thoughtful this affords little consolation. There is still less in the fact that the child, at least, knows when they are lies. I fancy that the word "gullible" is—if applied to one's self—the least attractive word in the whole English language. Yet how often even our wise (or only learned?) judges accept without question the "reasons" given them by youthful delinquents—the dime novel and the moving picture show. Either of these may be bad, very bad; though what Chesterton has claimed for the first in his "Defense of the Penny Dreadful" applies to the second, of course. The point here is that the youngster is sharp enough to see that the court accepts as *reasons* what he knows are *reasonable excuses*.

Common sense and discrimination are therefore indispensable even in dealing with children. Perhaps I should have said, "especially in dealing with children," for their ingenuous way of dragging in the nearest weathercock puts us at a great disadvantage. It's like a blow below the belt. It's not in the game as we play it, and we're never ready for it.

The wary investigator, whether psychologist, supervisor, or plain teacher must remember that in every field of observation there may be weathercocks; and, what is still more important, remember the child will see them first. And they turn and shift constantly. That is the way of weathercocks. They sometimes screech as they turn. Have you not heard them? In derision? Who can tell without a questionnaire?

In one way our methods are themselves quite like weathercocks; they are mechanical devices only. And like most machines they are not "fool-proof." There was once a man who thought the direction of the wind was determined by his own little tin weathercock.

BIOLOGICAL STATION WORK AT THE UNIVERSITY OF WISCONSIN.

The University of Wisconsin will open its biological station to investigators from June 15 to October 1, 1914. During the regular university summer session, courses will be offered in general zoölogy, general botany, heredity and eugenics, evolution, field zoölogy, teaching of zoology, dendrology, morphology of algae, mosses and ferns, morphology of algae, seed plants, plant physiology.

Professor M. F. Guyer will have charge of the zoölogical laboratories; Professor A. S. Pearse will give the field work. Mr. Nathan Fasten and Mr. A. R. Cahn will assist in the general zoölogical and field courses. Professor R. H. Denniston will direct the botanical work, and the other instructors in this department will be Professor E. M. Gilbert, A. Stewart, W. N. Steil, E. T. Bartholomew, H. E. Pulling and J. P. Bennett.

The city of Madison is admirably located for a biological station. It is surrounded by three beautiful lakes and the adjacent country affords a good variety of swamps, marshes, streams, woodlands and prairies. The station therefore offers excellent opportunities for outdoor biological work with all the advantages that go with the equipment of a large university.

For years surveys and investigations on the lake flora and fauna and their conditions of life have been in progress under the auspices of the Wisconsin Biological and Geological Survey, which has its headquarters in the biological laboratory at the University, and the result of these studies will prove of great value to all who are interested in limnology.

A thirty-foot launch capable of carrying a class of twenty-five has just been purchased and will be in commission throughout the summer. An adequate equipment of row boats, nets, seines, and other limnological apparatus is also available.

BOTANY FOR CITY HIGH SCHOOLS.[1]

By Elizabeth S. Rawls,
Shortridge High School, Indianapolis, Ind.

In coming before a body of teachers of this sort, I hesitate to say much of my own experience, since it is necessarily so limited. Yet I wish to bring to your consideration a problem which (I judge) is continually facing a number of you, as well as myself—namely, what sort of botany course is best for city high school pupils. I offer these few observations not as if they in any sense settled the question, but simply to give the point of view of one of yourselves, and to provoke if possible a general discussion in which we may present our individual difficulties for solution, or suggest to others, devices which have already proven successful.

Throughout the country a general outcry has arisen against the excessive theoretical training which has so long predominated in secondary education as a result of the college entrance requirements. Since but about five per cent of the total number of high school pupils enter college the demand that the ninety-five per cent who are using these schools as a preparation for life's work be given practical teaching is just. Their instruction should not be such that it will be merely a stepping stone to advance work, or valuable only for mental discipline.

In botany we have already taken heed of the demand to cast our teaching more in terms of real life than formerly, and are constantly striving to make the course applicable to daily life. But the question arises, how far shall the adaptation go? The answer to this will, of course, differ in high schools in country districts and those in cities. It is with reference to the latter that I wish to speak.

It is said that high school teaching for the benefit of the ninety-five per cent non-college children should have a strong vocational flavor. For us, does that mean agriculture? Statistics show that only thirty-six per cent of the total high school attendance will be engaged in agriculture, and, of course, but a small per cent of these will be found in the city schools. Although we would like to use our influence to increase this per cent, yet to give the course too agricultural a tinge would be to swing the pendulum to the opposite extreme, and be almost as detrimental as the former condition. This latter danger is a very real one,

[1] Read before the Biology Section of the Indiana Association of Science and Mathematics Teachers, March 7th.

just at this time when the state board of education has decided (in accordance with the state law) that agriculture shall be taught in all commissioned high schools.

Yet, let us take up for a moment the best interests of these agricultural students.

What would be the result of modifying our botany so that it dealt almost wholly with farm crops, field plants and the like, the so-called practical botany? A great part of the public would say "This is a step in the right direction." For in these days of rapid transit by means of locomotive, automobile, ocean liners, and airships, many seem to feel that a correspondingly speedy means of transporting our young people from a state of ignorance to one of wisdom is now in order, and that if we teachers were properly enterprising we could discover it. But following their inclination to its natural conclusion we would find that botany as a science would not need to exist; that it could be crowded into a corner as a more or less insignificant factor which might be sufficiently absorbed in small and tasty doses along with work on soils, animal husbandry, dairying, poultry and the like. Indeed we must take a firm stand, and advertise the merits of our system if we would hold our own.

The child who expects to manage a farm is the one most in need of science, and not a nature study such as agricultural botany is apt to degenerate into. A thorough mastery of the fundamental laws of botany, zoölogy and chemistry is essential as a ground work upon which to base scientific agricultural practice, for specialization of any sort is ridiculous unless it is established on a broad firm foundation. Knowledge of principles must precede their intelligent application.

Good stiff courses in botany, zoölogy, and chemistry should be prerequisite to agriculture proper. The present tentative state course, offering it during any year, obviously is planned with the idea in mind, of the pupil who drops out early, permitting him to get a smattering of all the vital topics, and letting him take what science he can at the same time. It is absurd to expect agriculture to be taught well without an understanding of plant morphology and physiology, and form and structure cannot be rightly grasped without a comprehension of phylogeny. It goes without saying that ecology is vital. Without a knowledge of these, the scientific farmer would be like the child who learns his geometry propositions by heart—helpless to work out an original problem.

An example of the product of such training is that of the man who took a short course in agriculture, and after his return discovered that his peach trees were badly infected with brown rot. He laboriously collected the mummies from these and threw them over his fence onto his next door neighbor's land. Similar is the man who with the best intentions of upholding modern methods places his faith in Bordeaux mixture as a sure cure for all insect and fungus ills. Or I might cite a case in which agricultural boys had charge of top grafting an orchard about ten miles from here. They attempted to do this by inserting the scions into heavy three or four inch stocks without providing wedges sufficient to relieve the pressure from the cambiums. They evidently had no clear conception of the delicacy of active growing cambium cells, or of stem structure in general, since they failed to take cognizance of the fact that the xylem of a tiny scion could not withstand the pressure of a three-inch limb. Of course, the undertaking was a failure. Such blunders cost not only dollars and cents but valuable time and the loss of confidence of the farmers.

But, it will be objected, they do go over these principles in any course of agriculture. Certainly they do, but unless their pupils are very different from most, "going over" is not enough. It might be for the brightest, but the industrial work has been established largely to make the person of medium ability more capable of holding his own in the world.

Assuming then that the basic principles of morphology, physiology, phylogeny and ecology are of use both to the pupil desiring to enter college and farm work too; what of the much greater per cent of city boys and girls who have neither end in view? Has the high school botany nothing to offer them?

They, as well as the agricultural student, would get little from the excessively theoretical and technical course so that our best average course would reduce that side to a minimum. On the other hand, they as well as the college entrants would get little from a course in which the farm crop phase was unduly emphasized.

The object of all of us in teaching is that, as a result of our work the pupil may become a better citizen, better equipped to enjoy a purposeful life in whatever community his lot may be cast. This third and largest group then presents us with the greatest problem in the achievement of this result. The question of just what can be done to make the year spent with us count most for these

individuals cannot be lightly settled. To begin with we cannot even assume that because they are taking our subject, botany, they have any knowledge of, or love for, plants. They may come to us because it is a required subject, or seems a lesser evil than cutting up animals in zoölogy, or anyone of a dozen trivial causes. Furthermore, when many of them live in flats and can have no first hand garden knowledge; when it takes some three-quarters of an hour by car line in any direction to reach natural woods; when many of the children cannot go on after school excursions because of parental objections to such trips, or because of working out of school hours in order to earn their way through school; the problem of making it a telling influence in their lives assumes alarming proportions.

All agree that the scientific method if thoroughly mastered will be of tremendous advantage to them in enabling them to make accurate observations, clear and honest records of the same, to draw their own conclusions and therefore become more independent of others for their ideas. Further, the information gained should help them appreciate the big problems and advances in agriculture, forestry, hygiene, preventive medicine, etc., and give an understanding of the life processes of nutrition, reproduction and inheritance that is applicable to their own lives. But these and many other desirable aims can best be gained if the impetus to the whole work is a love of, and interest in, nature.

To rouse this feeling it is necessary for them to become acquainted with numerous definite individual plants, for the number known by the average city child is pitifully small. The ideal way to do this, of course, would be to shut up the laboratory and take to the woods at a moment's notice without having to return the pupils on time to some other teacher's class—but until the millennium, perhaps, this will be unrealized by the majority of city teachers. Under present conditions the city teacher must keep his eyes open for any possible vantage spots along this line, for the success of this initial fall work gives zest to further study. A keen spirit of rivalry may be developed by making weed seed, or tree leaf collections in the fall or keeping a flower calendar in the spring. This often stimulates the laggards to put forth unusual effort, and if they can once be roused to acquire the "seeing eye" further work is not so hard.

To hold this newly awakened interest in plants long enough to really establish some love of nature is the next step, and economic botany, one must admit, focuses the attention of the child

of the high school age. I thoroughly believe in putting emphasis on the utilitarian side of botany wherever feasible. The advantages of this are manifold. An enjoyment and appreciation of plants that will be a lifelong source of value will never be developed by a detailed microscopic study of forms that are wholly foreign to him, nor by sentimentalizing over the beauties of nature. It may come from a realization of plants' direct influence on the pupil's daily life; on the high cost of living; of the possibilities of pleasure and profit they open up to him as a future owner of a home and garden of his own.

I approve of employing various devices for cultivating this interest. Experiments with seeds and gardening at home, gardening competitions, study of grafting, pruning and transplanting, add vitality to the study of structure. The economic effects of the fungi; the discovery of and prescription for plant ills on their own property; some knowledge of forestry, and plants as foods are all very much worth while. But how far shall we go with it all? Shall a scientific botany course have one vital part lopped off here, and another there in order to satisfy the demand for the practical?

At present all civilization seems to be going at a six cylinder rate of speed. The public is on a nervous strain such that it finds increasing difficulty in concentrating its attention. In the theatre the play with a central theme is gradually losing ground to the vaudeville stage and the moving picture show. It is not strange that this same atmosphere which permeates adult life should be reflected in the attitude of the children. Home life no longer furnishes adequate systematic training and discipline. Since their time is not occupied by home duties, there is an opportunity for numerous outside interests to distract their attention. Furthermore as the home has shirked its share of work, the school system has had to enlarge its scope and broaden its curriculum until even in the grades the children have their attention distributed over so many things that they lack the power to choose and master the really vital ones. This is not meant as a criticism of the grade school system. It is simply the result of a social condition in which the character of the home life is gradually changing and the schools have valiantly assumed a large part of the load. Nevertheless the fact remains that the teaching of these numerous and varied subjects produces in some of the pupils an attitude toward school more or less like that toward a vaudeville show, with a demand for rapid action and intense interest.

Personally I have no intention of staging a vaudeville performance. My purpose is not to equip the child to enjoy life of any sort, but a purposeful life which means a life of work. If he can become interested in the work, he is the gainer. But if not, he still must work if he is to be an honest citizen. Any character, worthy the name, must be acquired by conscious exertion of will power, and is never drifted into inadvertently. It is not our duty to make the pupil's path too smooth and pleasing for him. Since he is so soon to be out in the world fending for himself, it is only fair to him to get him into the attitude of mind where he will have faith to believe that thorough work is worth while, even though he can not at the time see the direct end to be gained by it. He should see that investing energy for the future does pay, otherwise everyone would be working with rapidly maturing crops, such as radishes and turnips; who would bother with the apple or the forest crop?

So while leaf collecting may be going on as outside work, in the fall, the outline of evolution need not be neglected, the algae can be studied at the same time in the laboratory. The fungi, of course, are of vital interest in and out of the laboratory. The work done in the Bryophytes, Pteridophytes to the Spermatophytes, is a pretty thorough test of the powers of both teacher and pupil—though it is the least showy of the year to an outsider. In the summary of evolution there is already a definite end gained for some, for others it may not develop for years. Or to cite another example, the development and structure of stems should be mastered even though it prove both difficult and tedious, since without this knowledge our future citizen will not rightly trim his own trees nor be able intelligently to direct the work of others. Numerous other cases could be mentioned, but throughout the course essentials should not be slighted for the attractive. If one or the other must suffer, let it be the latter.

In conclusion then I would say, that the course in botany best suited for the average city high school pupil should aim first: to give a broad acquaintance with common plants in order to instill in him an appreciation of plants and their relation to his own environment; and second, to teach the fundamental facts of plant morphology, physiology, phylogeny and ecology; to do this so far as is consistent with thoroughness with attention to the economic side, but never to lose sight of the fact that the object is a knowledge of principles, and that the economic emphasis is but a means to an end—namely, that he may be competent to cope with any ordinary biological problems that his environment may offer him.

THE FUTURE OF GEOMETRY.[1]

By Walter B. Ford,

Junior Professor of Mathematics, University of Michigan.

I trust that the title of this paper has misled no one into the belief that the author possesses a special gift of prophecy or that some message fresh from the famous Delphic oracle is about to be delivered into your hands. What I have to say may better be compared to the ordinary everyday predictions of the weather man who tells us of things about which, as we have often been pained to observe, he knows but little. But with all his faults we usually take him good-naturedly, and so I am led to hope that you will forbear with me today in my uncertain attempts to predict something about the future of geometry. In order to be clear, I shall find it desirable to begin with a few remarks upon the past and present status of the subject, more especially the present status in our own country. And let me add that having faithfully promised to read but a short paper I shall try to be brief.

We are told by the historians that geometry existed in a rudimentary form among the Egyptians but that they knew it only as a practical tool useful in the determination of lengths, areas, and the like. The Greeks in turn assimilated this knowledge and brought to bear upon it their characteristic fondness for pure speculation, with the result that geometry became elevated into a certain ethereal atmosphere peculiar to the Greek people and their philosophy. To rise ever higher in the realm of pure abstraction leaving reality in the dim background was the spirit of that philosophy. It was clearly one of the cloister and one which at best could effectively reach but a few disciples gathered about certain great leaders of thought. And thus it was, as the world knows, that the Greeks and their immediate successors, including Euclid gave to geometry a certain coloring, namely, that of scholasticism, which has persisted in it even to our own day.

Many have been the attempts to rid the subject of this particular coloring. We have seen such attempts in our own time and they have likewise occurred repeatedly at different epochs in history, notably in France during the seventeenth and eighteenth centuries. It is a fact, however, that all attacks directed in a radical spirit toward the complete abandonment of the scholastic element

[1] Read at the meeting of the Michigan Schoolmaster's Club in Ann Arbor, April 3, 1914.

in geometry have been futile. The reason for this is clearly the fact, which all who are here present today fully realize, that the chief value of geometry in education does not lie in its bare formulae and results, however useful these may be to the engineer or physicist, but rather in the training which the subject affords in well-sustained, connected thought and expression. I say that all efforts to banish completely the Greek ideal from geometry have failed, yet this, of course, is not saying but what we have tended to modify that ideal somewhat as the years and centuries have passed by.

Indeed, it is only natural that geometry, like the other sciences, should come to recognize in some sensible way that we no longer live in the age of Plato or Euclid. Thus certain changes have gradually in a conservative way taken effect. For example, it has long been recognized that the early beginnings of geometry may well be taught in a purely experimental fashion somewhat after the order of the laboratory method in the other sciences, and so inventional geometry, so-called, has long been taught, especially on the Continent, though it is utterly devoid of all formalism such as characterizes Euclid. Whenever introduced into the curriculum it serves as a forerunner to the deductive, formal side and thus tends to bridge over that chasm which every beginner feels if plunged directly into the latter from the start. Inventional geometery has, however, come but little into vogue in America, and apparently for the reason that its consideration in any serious sense aside from such exercises in pattern making, mechanical drawing and so on, as are now commonly done in the grades, would mean that we devote more time to geometry in our high schools than at present; and we as a people do not take mathematical studies seriously enough to feel that this would be worth while. However, what we can do and as a matter of fact are doing is to alter gradually old methods of presentation in ways that render geometry less artificial to the young beginner of sixteen years or thereabouts as he exists today in the midst of our complex life and civilization.

That changes to this end are in progress is perhaps nowhere better evidenced than in the increasing attention being paid everywhere to the so-called "applied problem." Such problems clearly tend to bring geometry home to the average pupil as we have him today, and most of us, I believe, are already convinced that when rightly handled such problems need in no wise detract from geometry's fundamental values. Thus, the applied problem

should not be over-emphasized, it should not imply some technical knowledge on the pupil's part which he cannot be expected to possess, it must be truly real and not of the made-to-order variety, it should never be inserted merely for its own sake in order to supply some interesting though irrelevant information about the arts and sciences and, lastly, its main object should always be to illuminate the geometric facts themselves. To be sure, the use of the applied problem is not in itself new, such problems having found a place for many years in isolated classrooms and text-books. The point that I would make is only that the value of such problems is at present being recognized generally in a way that makes them henceforth a vital factor in geometry.

It is the same with certain other changes which I shall now mention, though these may be classed as impending rather than as yet realized to any appreciable extent. They can perhaps best be explained by referring to the report submitted by the National Committee of Fifteen on geometry syllabus and published as recently as 1911 in SCHOOL SCIENCE AND MATHEMATICS.[2] First a word in passing as to the origin and purpose of that report and for this I can do no better than quote as follows from the report itself[3]:

"At a meeting of the National Education Association in Cleveland in 1908 the mathematics round table of the secondary department, numbering some two hundred members, unanimously called for a national committee to study and report upon the question of a syllabus for geometry. In December, 1908, the American Federation of Teachers of Mathematics and Natural Sciences at its meeting in Baltimore authorized the appointment of a National Committee of Fifteen on geometry syllabus. At the Denver meeting of the National Education Association in 1909, the secondary department authorized the committee which had already been appointed by the American Federation to proceed under the joint auspices of the two national bodies. The committee thus constituted was made up of eight representatives of the secondary schools and seven representatives of universities. After an extended preliminary correspondence in which each member of the committee submitted to all the other members a full statement of his views on all phases of the work in hand, including desirable methods of procedure, the investigations of the committee were conducted in three subdivisions of five members each. These subcommittees carried on their work by correspondence and in some cases by meetings of their members during a period of a year and a half, the results being submitted from time to time to the general committee for suggestions and criticisms."

I will not consume the time of this meeting to read the names of the committee, but anyone who takes the trouble to consult the report, which is most interesting throughout and carefully

[2] Copies of the Report in pamphlet form may now be obtained *gratis* upon application to the Commissioner of Education, Department of the Interior, Washington, D. C.

[3] See report, page 1.

done, will at once recognize in the list of fifteen some of our best known educators in mathematics, both within the high-school and the university circles. The deliberate findings of such a committee should have weight and I believe they have already had an appreciable effect in shaping our future educational policy as regards geometry. But, to return to my subject, the point I wish to bring out is that this report advises a goodly number of what are termed "informal proofs," by which is meant no proof at all in the primitive Euclidean sense, but rather a mere acknowledgment of fact accompanied by abundant illustration drawn from everyday experience. This at first thought sounds like a dangerous practice, and one likely to undermine geometry as conceived usually heretofore. Indeed, like the applied problem, it can doubtless be pushed too far, or even misapplied altogether. Still, when we consider the honest fact that geometry in a strictly logical sense is not to be found in Euclid, nor does it exist even to this day except in the modern researches of highly trained mathematicians, while they themselves are not agreed as to the precise form it may best take, we begin to see the justice in merely stating facts now and then rather than shamming proofs about them as we are unconsciously doing now. The situation in these matters affects especially the early theorems of Book I and some of those in Book II and to a considerable extent the theorems in solid geometry.

In order to be a little more precise, I quote the following theorems which the report recommends be treated only informally. These are merely selected samples, but among them I think you will easily recognize some for which we are commonly attempting formal proofs today:

1. All straight angles are equal.
2. Only one perpendicular can be erected from a given point in a given line.
3. Two lines parallel to the same line are parallel to each other.
4. Vertical angles are equal.
5. Complements of equal angles are equal.
6. Supplements of equal angles are equal.
7. The bisectors of vertical angles lie in a straight line.
8. A diameter bisects a circle.
9. A straight line intersects a circle at most in two points.
10. If two planes cut each other their intersection is a straight line.
11. Two dihedral angles have the same ratio as their plane angles.
12. Every section of a cone made by a plane passing through its vertex is a triangle.
13. Every section of a cylinder made by a plane passing through an element is a parallelogram.

These, then, and a limited number of others we may soon expect to see proved only informally if the position of the com-

mittee is right. Here again we see the tendency to make geometry more real and natural to the beginner at a certain sacrifice of the purely formal and traditional.[4] Without stopping to mention other clearly discernible influences now at work to mold our present day geometry and that of the immediate future, let us pass on and ask where these tendencies now so well initiated will be likely to end. To be sure we cannot predict with certainty, but are there no signs that point to what the more distant future has in store? I believe there are such signs.

We are told that during the last century there lived in Germany a great musical genius. Before his day music had been constrained by time-honored formalisms, so much so that in breaking away from them this man became altogether misunderstood for many years. Yet his own work at last brought the world to a full realization of the fact that music need not lose all through the enjoyment of a greater freedom. Indeed, he showed how it is tremendously enriched by such a freedom. The critics while they lasted were bitter. They said "This man, this Wagner, this author of Tannhäuser, of Lohengrin and so many other hideous things . . . and above all, the overture to Der Fliegende Holländer, the most hideous and detestable of the whole . . . this preacher of the future, was born to feed spiders with flies, not to make happy the heart of man with beautiful melody and harmony. . . . Wagner's theories are impious. No words can be strong enough to condemn them; no arraignment before the judgment seat of truth too stern and summary; no verdict of condemnation too sweeping and severe. . . . All we can make out of Lohengrin by the flaming torch of truth is an incoherent mass of rubbish, with no more real pretension to be called music than the jangling and clashing of gongs and other uneuphonious instruments. . . ."[5] As we today read these fervent but miscalculated lines let us ask wherein lay the secret by which Wagner revolutionized music. The answer is clearly to be found in his one all-absorbing ambition to make music more real. To this end he unhesitatingly abandoned tradition at times and seemed to his contemporaries to overstep all bounds, yet withal we see in him today not a destroyer of the old but a builder, breaking away from the past only where necessary to enter the larger and better new.

[4] Another noteworthy report in which much the same conclusions are reached is that of the committee of the Association of Mathematics Teachers in New England, published in 1906.

[5] From the *London Musical World* of June 30, 1855.

No doubt you have already drawn the inference which this bit of allusion affords. As in music fifty years ago, so in geometry today we are too much fettered by tradition. We need to make more boldly the formal, indispensable and valuable as it is, the servant of the natural, and it is precisely this that the new era already impending is to accomplish. We see the dawnings of this era in the general acceptance of the applied problem, in the limited use of the informal proof and in other growing tendencies and it only remains perchance for some genius again to clear the way and bring us face to face with the wider vision.

MATHEMATICS IN THE EDUCATION OF GIRLS.[1]

INA EMMA HOLROYD,
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The place of any subject in the school curriculum in these days of overcrowding must be justified, it seems to me, by one criterion only, that of value. By value I do not mean its measure in dollars and cents, but rather that larger value to one's self and to those with whom one comes in contact, of satisfaction in understanding, of enlarged view upon life, of increased power to think and to do.

Mathematics holds and will continue to hold a large place in the education of girls because it can justly lay claim to more such points of real value than perhaps any other single subject. This is probably due not only to the peculiar nature of the subject but to the fact that no other single subject, except the mother tongue, so permeates every phase of life and is so necessary to the successful conduct of human affairs.

Those who object to its importance for girls base their objections largely upon the following arguments: lack of interest, lack of utilitarian value, and strain of the nervous system. It may well be questioned whether girls really do lack interest in mathematics. It certainly has not been my experience nor that of a number of others whom I have consulted. I am wondering how much of this alleged lack of interest is due to the nature of the subject and how much to failure on the part of teachers to make the subject vital by seizing every opportunity for establishing connections with everyday life, of making their subject function in the general scheme. Certain it is that no teacher who believes in

[1] From a paper read before the Mathematical Club, Kansas State Agricultural College.

his soul that girls should not be required to take the subject will ever present it with the lively interest of one who feels intensely its value to them.

I do not maintain that all girls should study all mathematics any more than that all boys should take an engineering course. Teachers tend to enjoy pupils who do the work readily and elegantly. It is a satisfaction and is much easier than to toil with those who do not put their work to a so-called practical use and make a brilliant showing. Therein lies one test of a really large-hearted and broad-minded instructor. Are you willing to do thoroughly and conscientiously that which must mean so much to the many "just common" intellects? Do you so value your subject that you feel deeply convinced of its inherent worth to the world? Are you willing to toil, knowing that you will probably never see the results, yet knowing that, because your subject is so valuable, the results are certainly there? It is not a question, as I conceive this subject, of the best subjects for girls to specialize in, but of the best subjects for the foundation of a general education. The results of collective experience must be interpreted by broad-minded men and women from the viewpoint of the kind of men and women they desire to see grow up.

Suppose teachers should vitalize the subject of mathematics by the presentation of a sufficient number of real problems to whet the appetite and to show the usefulness of mathematics as a preparation for life. Suppose the girls should measure their own rooms for paper and for floor coverings, decorative friezes and dados; their windows for shades and draperies; their pictures for frames; should figure contents of flour and sugar bins; should draw to scale plans of houses with calculations for cupboard and closet space; should figure proper radiation surface for given rooms; should understand the plumbing systems and the electric wiring of their homes; should be able to read the water, light, and gas meters; should keep household accounts, and read market reports; should know how to estimate the proper amount of material for the making of table and bed linen, clothing, and so on; should be able to enlarge or reduce patterns to scale; should figure the amount of ruffling for a skirt of given width in order that it may "full" in a given ratio; should know, without guessing, how much lace and other trimmings to buy for a given purpose; should know how to construct decorative designs, such as regular polygons, five pointed stars, for covers for boxes, stools, window seats, cushions, and em-

broidery designs without number. Do you think they would lack interest? And all this may be done without cutting the heart out of the subject or losing any of its disciplinary value. One of the interesting features of mathematics is, or ought to be, that it requires effort and carries with that effort the inspiration of mastery.

I do not see that we should esteem mathematics less highly even if we admit that its utilitarian value is probably somewhat less for girls than for boys, though perhaps we should pause to consider just what we mean by utilitarian value. If we mean bridge building, steel construction, electrical inventions and applications, canal digging, and so on, that, of course, is apart from the average girl's experiences, though I am very certain that a large number are deeply interested in these matters and enjoy reading about them. If we mean the application of mathematics in the successful carrying forward of a home, in its business management, in the respectful and helpful companionship of its children for women in homes; if we mean the almost absolute necessity of arithmetic, especially, to women who must compete with men in the business world; or if we consider the vast amount of computation done in our laboratories and observatories, much of it by women; then its utilitarian value is certainly high to those who need it. Again take the change in the educational situation in our country in the last decade. Four states now have women at the head of their school systems. There are now four hundred ninety-five women county superintendents, double the number of ten years ago. In some states women appear to have almost a monopoly of the higher positions of the public school systems. In one state of thirty counties only one man is holding the position of county superintendent. A number of cities have women superintendents. Together with the advancement of women in the administrative branch of education has come a demand for women on local school boards. The following large cities which number women on their school boards show how widespread is this condition: New York, Chicago, Cleveland, San Francisco, Milwaukee, Washington, Indianapolis, Rochester, St. Paul, Denver, Columbus, Worcester, Grand Rapids, Cambridge, and Fall River.

I do not intend to enter into a discussion as to the desirability of this condition. The future will decide that question, but I state it as a situation which confronts us whether we will or no, and a situation, moreover, which we must meet, gripple with, and conquer that our future may be worthy of us.

Possibly for most girls the traditional education of boys has been too closely followed; but we should not rush to the other extreme of assuming that the minds of all boys are constructed upon one model and the minds of all girls upon another. Personally, I do not believe that there is necessarily any greater differences between the mind of the average boy and of the average girl, than between that of two individual girls or two individual boys. Every individual should have the opportunity to develop upon all sides. Girls have minds, a great many of them very good ones, too, and if educated at all, will take interest in the wonderful advances in sciences which are all about them in the world today. Mathematics underlies all science, especially physics and chemistry, two of the sciences about which there appears to be no question as to girls pursuing, since they have such vital connection with everyday life in the home.

But apart from these very important considerations, there are other advantages which we can ill-afford to take from our girls. All girls ought to develop into reasonable beings, able to think and to talk to the point. They ought to acquire accuracy in the use of language. Mathematics properly taught will greatly aid to both ends.

Manipulative skill and rapidity of calculation may well be left for the training of specialists. What girls in general need from the subject is to be made to think and to think to an end. The subject of mathematics, especially geometry, is a rich field for the cultivation of habits of "why," "because," and "therefore," for which many a woman and, I venture to think, many a man also would be the better.

One of the important values of mathematics in education is that it is difficult. It requires powers of concentration and attention. Inattention is harmful to any subject, but to mathematics it is fatal. It is this concentration which causes the fatigue and consequent nervous strain complained of. It taxes many girls' powers to the utmost. Probably most girls should at all times do less work than their brothers and this is one of my reasons for believing as I do that at least in some subjects girls and boys between the ages of twelve or thirteen and eighteen or twenty would do better work in separate classes. However, strength is not gained by removing strength-giving subjects from the curriculum, but rather by a judicious use of these subjects. Let a girl observe regular habits of eating and sleeping, of suitable exercise and sport, of moderate social indulgence and sensible

dressing; but let her work and work hard, let her learn to appreciate what real effort means, let her fill her mind with food for thought and varied interests in life to replace some of the domestic duties of which the changing industrial conditions have robbed her. She will be none the less feminine and interesting and none the less womanly and domestic, for she will not then be the discontented creature that so many of the uneducated women, robbed of former duties, now are.

I would not, if I could, make a Madam Kovalevsky, an Agnes Clerke, a Wilhelmina Fleming, a Phillipia Fawcett, a Mrs. Sommerville, or a Madam Curie of every girl. But for those who have the ability and inclination, the physical vigor and the money, I do not see that any one should say them nay if they desire to enter the field of mathematics. Men should recognize and appreciate that the determined movement on the part of good women for higher education is a natural, legitimate, and womanly condemnation of the frivolous lives of so many discontented and idle women; and that if they are not mothering their own children, they are mothering the nation until such time as it shall have ceased its unrest and readjusted itself to the new order of industrial conditions. In the meantime, let us not rob our girls of any right to a many-sided development and let us leave it to them to demonstrate whether they are worthy to carry forward the burdens of their generation as we have striven to do in ours.

GRADUATE WORK IN MATHEMATICS.

Dr. Wilczynski of the University of Chicago during the autumn and winter quarters of 1913-14 gave a course in projective geometry at University College. The students in the course, teachers of mathematics in the Chicago high schools, were unanimous in their appreciation of it and in their desire that another graduate course be given in the autumn of 1914. Dr. Wilczynski has consented to offer such a course, probably in advanced calculus. This is an exceptional opportunity for teachers of mathematics in the city and suburban schools to do graduate work under a man of distinguished scholarship and of rare teaching ability. The class of last fall unite in their testimony that his lectures are remarkable for their clearness and interest and are sending out this notice in the hope that a large number of their fellow teachers may avail themselves of the privilege of enrolling in the course in September.

Bulletins can be secured from the University of Chicago. The sessions will be held at University College in the Bryant and Stratton Building on E. Randolph St.

THE TEACHER'S CONCEPTION OF PHYSICS.[1]

By G. W. Stewart,
Professor of Physics, State University of Iowa.

Perhaps none of us have forgotten the days of athletic contests in which we had a part. In those contests our errors were satisfactorily explained by defects in our equipment or lapses in the quality of the game played by our team-mates, and, indeed, so biased were our judgments that the errors of opponents were interpreted as excellent performances on our own part. As teachers of physics today we are just as fallible. If we do not succeed in our teaching it is the equipment, the text, the laboratory manual, or a new method that is at fault. The limited horizon of our vision of physics is never the admitted secret of failure, and yet that vision is the most fundamental of all factors that we can discuss. The selection of my title, "The teacher's conception of physics" is a recognition of this entirely natural and ever-present condition. I should not be willing to attempt to impart information as to how the members of this Association should teach physics, but I ought to possess a degree of confidence in a discussion of the actual attitude of the teacher or anyone else toward this great study, physics. My desire is, therefore, that in this discussion we abandon concrete problems of physics teaching and attempt to form a vision of that attitude toward physics which should be the chosen one for the physics teacher.

What should be the teacher's conception of physics? This query cannot be answered in a few sentences, for there are many aspects of physics, and the differences in our conceptions are largely due to the differences in the relative emphases which we place upon these aspects. It will be necessary to discuss separately several of the more important phases of physics if we are to secure an appreciation of the proper balance of emphasis for which this paper contends.

Most elementary text-books of physics discuss units and measurements in the first chapters; most laboratories ask the student to perform experiments in measurement as an appropriate introduction to laboratory work. A consideration of possible accuracy in physical measurement has always been attractive to the student because it has presented achievements of physics in a form capable of ready appreciation. But do not teachers as well as pupils acquire an appreciation of accuracy of measurement so marked that

[1] Read before the physics section of the C. A. S. and M. T. at Des Moines, Iowa, November 28, 1913.

an unconscious and yet an overshadowing emphasis is placed upon that feature of physics? Is this emphasis justified? Is accurate measurement the real heart of physics or is it an accompanying necessity? Let us turn to our research laboratories for the answer. Examine the contributions fresh from these laboratories and you will conclude that physicists actually avoid accurate measurements. The research physicist attempts to go straight to the essentials of the matter under investigation, he makes only measurements that are necessary, and he seeks an accuracy no greater than the desired results demand. True, new discoveries have been made through sheer accuracy, but this is certainly not *the* method of extending our knowledge. Indeed, physical research is merely the tracing of clues by the use of any method and every method that promises a result. The real work in physics is then not accuracy of measurement but the pursuit of truth. This is well illustrated by the progress made in radioactivity and in the study of atomic structure. Here one forgets human skill in manipulation and marvels only at the ability of the mind to press forward into an apparently impenetrable unknown. Emphasize accurate measurement because of certain educational value if you will; but you thereby endanger the correctness of the vision of the student. One cannot justify practice in accurate measurement upon the ground that such practice will some day be of direct service to those of your students who will become engineers or scientists or will enter the field of research.

Another aspect of physics, emphasized by all text-books, is its classification of present knowledge. Undoubtedly classification is necessary, but it should be regarded as a method devised for the sake of expediency and not for the purpose of giving the student a keen appreciation of physics as it appears in the world about him. That there is a strong tendency to look upon physics as essentially a classification, seems indubitable. Can there be any real value in learning the description of a lever of the "first class?" I fail to detect such a value. As a matter of fact we should be somewhat ashamed of our own minds if they grasped at such valueless classification. Physics in nature is not classified. Mechanics, heat, light, electricity, etc., are quite likely to appear simultaneously not only in nature but everywhere, and the conception of physics as a classification would close our minds to the appeal of omnipresent physics. Classification is essential if we are to convey information the most rapidly, but we sometimes act as if our function was to create encyclopaedic minds rather

than to invigorate and to inspire the normal minds that have real tasks to do. Encyclopaedias are cheap, but men and women who are able to solve the everyday problems which come before them are rare. The greatest asset of the problem-solver is the correct attitude of mind. Our effort should then be directed in the creation of this attitude and in the relegation of classification to its function as a necessary means, the use of which is to be reduced to a minimum.

Let us turn to another aspect of physics. This one is found to be due to a characteristic common to human nature. Always have men welcomed revelation as complete and final. There seems to be an innate desire to place revealed science as well as revealed religion upon the pedestal of infallibility. We do not desire to mislead our students in regard to physics, and yet unless we are especially warned and are unusually cautious we will give them a conception of physics as a fixed body of knowledge, indeed, fixed because no modifications can be made in the "fundamental laws" and because the chief facts to be learned have been already accumulated and classified. We teach our students the "principles" of physics and by this term we mean the fundamental truths in that subject. As a matter of fact they are neither fundamental nor are they probably truths. A fundamental truth once ascertained needs no further investigation, for it is fundamental, and that which does not need investigation is of no special interest to the scientist or to an inquiring student. It is true that the student naturally seeks explanations in final terms and an attempt to satisfy him by a proximate explanation ends in a certain type of failure. To some that failure is a matter of regret, but we ought rather to believe that the complete satisfaction of the student's mind would be a great disaster. A course in physics is not for the purpose of satisfying the student's mind, but it is rather for the purpose of conveying to him a true but simple picture of physics and our present knowledge of it. We do not wish our students to believe that these so-called "laws" are accurate statements of the actual physical laws, for this belief would cause them to have less of an appreciation for and an interest in the physical phenomena of the world about, and it would dull their spirit of inquiry. Attaching the discoverer's name, as in Boyle's law, does not seem to be an effective method of preventing these influences which are detrimental to the cultivation of the appreciative and inquiring mind. Our only salvation is in a correct conception and in a determined resistance to the student's desire

for accurate and unchanging information. The most elementary "laws" in physics are of great interest to the physicist because they are but approximations of great truths, and because in each there is mystery so profound that we cannot hope for its solution within any finite time. An appreciation of this interest does not require a knowledge of more than the most elementary facts.

But it is very easy to convey a false impression not only as to the nature of our "laws" but also as to the actual quantity of knowledge that is today in our possession. Is it not a student's right to have the opportunity to cultivate the correct perspective, to see that in the future our knowledge of the principles of physics will be greatly extended and to realize that in every portion of physics the quantity of the known is exceedingly small when compared with the unknown? The usual perspective that we give our students is confined solely to the region existing between the covers of our texts, and the resulting vision is not wholly unlike a painting of a beautiful landscape by an inartistic novice. There are enough strokes of the brush, and there is enough paint, but there is no vision and hence no landscape. We teach enough, but we need to give the vision.

Our discussion of the nature of our so-called "laws" and the student's demand for unchanging information at every point in his study of physics leads to comment concerning physical theory. Many teachers are much annoyed by threatened changes in any theory, for these produce a fear which destroys complete reliance. Some would prefer to teach the electromagnetic theory of light as the final word. But unfortunately, certain facts indicate that it is not true. What ought they to do? The answer is simple. They should teach that which is in best accord with experimental evidence, namely, the electromagnetic theory of light. But they would reply, "How can I teach a theory that is not true?" I answer by the question, "How can you teach a theory as true?" Theories in physics are not given us as infallible doctrines but as aids to the acquisition of new knowledge. They will change continually, only so will physics ever evolve into a greater and more profound science. The students may not prefer this conception. In fact, another impression of physics would win a greater respect on their part. But we must have confidence that the correct conception, though not so welcome, will in the end give our students greater power.

Let us turn to the consideration of another aspect of our in-

struction in physics. We do not study physics by a method similar to what is known as "the case-method" now adopted by most colleges of law. We do not ask the student to ascertain a principle from the study of "cases" or phenomena but from the study of a book, and the subsequent experiments in the laboratory serve as a verification of the book. The result is that not only the students but we ourselves have come to regard physics as a thing in the book, as a record of what we have learned and classified. This conception of physics is in harmony with the definition of "physics" in our best dictionaries, yet it is this conception against which I wish to protest. In "physics" we should include all physical law, known and unknown, and physical law exists where the phenomena occur and nowhere else. But the immediate environment of the teacher directs his attention to the laboratory and to the text. In the former he finds the operation of the experiments are not like the actual phenomena in nature and in the latter the definitions and descriptions are not closely related to the world about him. So we teachers fall very quickly into the serious fault of confining our interest in physics to our laboratory and to our textbooks. Our students are thus deprived of the helpfulness of the best sort of illustrative material and they fail to gain that increased interest in the wonder of the world about them which is an essential part of their education. It is also true that their knowledge, because less related to their environment, is thereby less available for service.

The discussion of the view of physics as knowledge in books leads us naturally to a brief consideration of the teacher's attitude toward applied physics, for the attitude will be determined by the teacher's conception of physics. Toward applied physics many teachers are unsympathetic. This feeling is in some cases born of ignorance, but in others is caused by the incorrect notion that physics which occurs in the many devices of man is not actually physics, but engineering. But engineering is physics; indeed it is part of the fruit of many years of valuable scientific effort. The achievements of engineering should be an inspiration to every teacher and should give the student a vision of the perspective of the real scientist, the man who labors unostentatiously in his laboratory with a vision that the knowledge he gains will some day be of direct service to society. Let none of us fear to draw upon the field of engineering for illustrative material in our class-rooms, for the difference between pure science and applied science is merely one of perspective, the former having a vision of tomor-

row and the many centuries to come, and the latter having its attention focused more closely upon the problems of immediate importance today.

The discussions in the physics section of this meeting will emphasize vocational physics. Inasmuch as our conception of physics has a direct influence upon our attitude toward vocational physics, we ought to be able to derive certain conclusions from our present discussion. Some teachers object to teaching vocational physics on the ground that such a course is not really physics but merely a collection of practical facts which, although interesting and immediately helpful to the student, cannot give him a broad basis for growth. The fault with such an argument rests in its assumptions that it is possible to teach the subject of physics in a year's work, and that the function of all education is to give a broad basis for growth. The first assumption is the only one I shall attempt to discuss. From our previous discussion the error in that assumption should be obvious, for no one teaches in any year's course more than a minute fraction of even the known physics. As a matter of fact, every course is one in selected physics. The selection which we choose to offer our students should depend entirely upon those students, their ability, their probable future and their immediate interest. I fail to see how a teacher is degrading either himself or his subject if he makes a serious effort to accommodate himself to the students, perchance by teaching several courses adapted to various needs, provided that the teacher in each course gives the student that vision which will be appreciated and which will mean the greatest growth. Teaching without a vision is always degrading no matter how advanced or how difficult the subject. But teaching with a vision is always elevating no matter how elementary the course may be. Of course I do not contend that in our decision as to the needs of the students we think only of today, for education for any specific career must always be broader than the immediate demands of that career. But when the needs of our students have been determined there is no objection to the selection of a course in physics that will satisfy those needs.

There is an aspect of physics that is the cause of many troubles in our teaching. I refer to the difficulties arising in the mathematical formulae and the solving of numerical problems. There is much that can be said concerning these difficulties, but the conclusions can be reduced to a few simple statements. Physical law exists irrespective of mathematical symbols and processes. In

our attempts to state physical law briefly and to propose new theories which will lead to progress in physics, we are compelled to use mathematics. It is indispensable. But we must clearly see that the use of mathematics arises because of our need of such assistance. The function of mathematics in physics is not to confuse, but to enlighten, not to make physics more difficult, but to make progress easier. Why not use mathematics in all physics teaching in precisely the same manner? The answer is obvious. The adoption of this view of the function of mathematics in physics will certainly not remove all our difficulties arising in the mathematical aspect of physics, but it will give us a basis for guidance in our insertion or rejection of mathematical formulae in our teaching.

You have in mind that I have described a conception of physics that demands of each teacher the spirit of the physicist, and you are at once ready to assert that the average physics teacher cannot possibly secure the training requisite for the cultivation of the proper conception of physics. Perhaps your assertion is true. It is for us, however, to set the standards of our own profession. That man who does not recognize his own limitations and who permits himself to be swayed by his environment is an object of pity to his friends and a cause of discredit to his profession. It is to our own interests and to the interests of our profession that we place our ideals high and then strive with all our might to reach them. We must not be content to permit the teaching of physics to be domineered by wrong conceptions. The more we specialize in our teaching the greater the responsibility we have toward the proper conceptions of our subjects. Those who teach physics as one of several subjects should attempt to get a vision of each of them by studying in the summer sessions in departments alive with research. Those whose time is devoted solely to physics should by all means have the experience of actual research, which means approximately the attainment of the Master's degree. We must not blame method, the text-book, the laboratory, but we must determine upon the necessity of our own growth.

You have been asked to consider several aspects of physics and perhaps the criticisms offered have pictured to you the conception that is desired for the possession of every teacher of physics. But let us review them. The teacher cannot permit the interest in accuracy of measurements to deprive him of an interest in what might be called "real" physics. He will not allow the subject of physics to be divided into six or seven parts which are to be placed

in separate compartments in the mind, unless the confining walls of these compartments are no more than the thinnest of fabrics inserted only at the demand of pedagogical efficiency. He will think of physics in its proper relation to the achievements of the past and the possibilities of the future. To him the interesting and highly important applications of physical law in our complex life are but glimpses of the unlimited attainments of the future. He will not be content with physics as represented in many-volumed libraries but will have a vision of physics as universal physical law, which we understand only in a small part. Such a teacher cannot get his inspiration from a printed page whose content is presented in a form to satisfy the educational requirement that our students learn facts rather than that they contemplate important and partially understood truths. His inspiration comes from the world about him where is the dwelling place of omnipresent physical law. Our contention is that the present limited knowledge of physics must not be believed to comprehend the real physics, but only to contain approximations in that small part of physical law which has come under our observation. Our known physics should not be likened to a pier of solid masonry which grows year by year, each addition becoming a permanent portion of the structure, for then we would lose interest in past achievements and look only towards discoveries in new fields. But our known physics is more like a fibrous ramification into the truth, the real physics, at no point coinciding with the truth, and at all points of its many branches furnishing the seeker merely an approach to truth. Textbook physics is not a collection of dogmas which because of their infallibility must attract men, but it is a distinctly human document inspiring because its limitations arouse hope and zeal in the heart. And it is the dependence everywhere of the material universe upon physical law that produces in the teacher an intense yearning to penetrate behind those general and proximate statements recorded in our texts. This yearning is not without hope, for a realization of the meagerness of our comprehension will cause him to expect the discovery of many unsuspected truths in his own generation. Much of the progress of our day is made possible by steps so simple that they are readily understood by a high school student, and this encourages us to believe that in our own class-rooms there are boys and girls whose contemplation may some day lead to discoveries of great importance. In the advances of the past few years we have been taught the possibility and indeed the probability of explaining matter in terms of the invisible atom of electrici-

ty and we have thus been led to regard the realm of sense perception as but an expression of the unsensed and unexplained. The real physics thus appears not to be further removed from our daily lives but to be growing in our appreciation as a group of fundamental relations which, though realized but in part, must comprise an immanent and all important reality. And how can a subject of such significance and such incompleteness become common-place in the minds of the students? Only through the commonness of the mind of the teacher; only through a vision on his part that does not measure up to the conception we have discussed.

In our presentation much has been said of a negative character. Let us repeat some of the positive suggestions. The teacher of physics sees the limitation of text-book physics both in scope and meaning; he realizes that the known physics is but an approach to truth and that the real physics exists where the phenomena are, indeed that physics is an immanent thing; he recognizes the value of contemplation of partially understood truths and the relation of these to the achievements of the past and the future, and he believes that our knowledge, though meager, should inspire every student.

This paper cannot be brought to a close without the frank admission that a discussion of this kind seems to many not sufficiently definite, and hence not clearly helpful in everyday teaching. The only defense to be offered is that the paper proposed to discuss a conception of physics as the most fundamental factor in teaching, and this with full recognition that the discussion would prove helpful only where it encouraged the possession of that conception. The preparation of the paper indicates my own belief; your approval or disapproval of the various opinions stated indicates your belief. But the vision does not need believers; it needs possessors. The possession of the vision is a most practical thing. Physics is a great field for human endeavor and we must cultivate the possession of a vision that will measure up to it. Then, though we may have many imperfections in our methods of teaching, we can inspire minds to serious contemplation and encourage our students to become men and women of power in whatever field they may enter.

PHYSICS IN THE GRADES BELOW THE HIGH SCHOOL.[1]

By John H. McClellan,
Emerson School, Gary, Indiana.

Part 1.[2]

The purpose of this study is not to provide a vocational course in physics. A vocational course would be impracticable for two reasons. In the first place, children in the grades are too young to begin vocational work. The compulsory school law, of the state of Indiana, makes it more feasible to introduce such a course in the early part of the high school period. A far more valid reason, in the mind of the author, is that the subject of physics, in its entirety, can never be made vocational. If we actually vocationalize physics, we shall, undoubtedly, vocationalize it piecemeal. When that day comes, we shall have *vocational mechanics, heat, optics, and electricity,* and these again shall be sub-divided and redivided. This will be expensive both from the standpoint of instruction and equipment. In the more specialized industries this is best done in the various factories. The Westinghouse and General Electric Companies already maintain apprenticeship schools in connection with their industrial plants. However, the day of real vocationalized physics, in the public schools, is much farther distant than our popular magazines and Sunday newspapers would have us believe. We are not antagonistic to bona fide vocational training, in any line, but we are utterly opposed to the great mass of educational rubbish which is now being thrust at us labelled *"vocational."* The various ramifications of physical science can be fully and effectively made helpers in winning bread when there is a more reciprocal coöperation between the school and the manufacturer—when part of the time of the student is spent in the factory and part in the school—as at Fitchburg, Massachusetts, Cincinnati, Ohio, and Chicago,[3] Illinois.

There are only a few places in the United States where portions of the subject of physics have actually been organized to serve as useful and immediate aids in making a livelihood. The books recently published by one of the technical publishing companies are fine examples of what competent men can do when given the time, equipment, and opportunity. This is the only way the subject will be vocationalized. Professor Timbie has

[1] Copyright 1914 by John H. McClellan.
[2] Read before the Physics and Chemistry Section of the Indiana Association of Science and Mathematics Teachers, held in Indianapolis, March 7, 1914.

[3] Austin High School and Western Electric Company.

given us a book on electricity,[4] for practical men, with subject matter that is remarkably teachable and well adapted to its purpose. *Schools looking toward vocational electricity, must expect to employ men who are not only well versed in mathematics, chemistry, and advanced physics, but also men who are familiar, by actual work, with industrial conditions. Need I add that they must be teachers as well?*

The course which is here presented, aims, only, at giving accurate notions of some of the fundamental physical phenomena. It seeks, first of all, to answer some of the many questions which the curious boy or girl is putting to himself, his associates, and his elders. The primary aim should be to keep alive the scientific or investigative spirit with which every normal child is endowed.

We claim no originality for the subject matter of this syllabus nor for the idea of teaching science in the grades. Neither do we regard it as the best possible arrangement. We are quite certain that this work contains many imperfections and we present this solution to the problem merely as an example, which may help others to solve their problems in a more satisfactory manner.

In these schools, the science work begins in the fifth grade and continues, theoretically, at least, throughout the high school course. The odd years are given over to the subjects of physics and botany, which include elementary physics, physiography, advanced physics, seed distribution, gardening and formal botany. The even years receive instruction in chemistry, and physiology or zoölogy.

Out of the time of an odd year's work in the grades the teacher of physics is allowed only thirteen weeks. He has these pupils for sixty minutes each day during this interval. The other two sections of the class go either to shop activities or music. To recapitulate, we have a grade boy in physics thirteen weeks out of his fifth year and the same length of time in his seventh year.

The work for each day has been carried out in the following manner. On Monday morning a hectographed copy of directions and a blue print of the apparatus, as assembled for the experiment, are placed in the hands of each pupil. The children are first given an opportunity to peruse the experiment themselves. The instructor then reads the directions of the experiment over with the pupils to make certain that there are no misunderstandings. Occasionally, when the experiment seems to be extremely difficult,

[4] Elements of Electricity for Technical Students.

a set of apparatus is at hand on the demonstration table and the instructor gives limited directions regarding the method of procedure. If the pupils are really interested in the experiment they will have sufficient questions to consume the whole recitation in preliminary discussion. At any rate they will barely get started on the exercise the first period. The second day is given over entirely to the children for work on the experiment. During the progress of the laboratory experiment the instructor has found it advisable to answer very few questions. One of the main purposes of giving laboratory work should be to prompt self-reliance in thought and to foster the spirit of discovery and invention. Children often ask questions for the same reason that a novel reader looks in the last chapter of the book.

The third day, the instructor takes up the experiment part by part to make sure that right conclusions have been drawn. He does not, however, try to hedge in the pupils' thinking within the limits of the object of the experiment or even within the limits he had originally thought were valid. Original ideas and originality of thought on the part of the pupils are encouraged above everything else. Unfortunately, much of the science teaching in the past has killed originality by insisting on uniformity. At this particular place in the work the instructor can introduce the work-a-day applications with which the children of the community are familiar. Although the same general outline is given to boys and girls alike, the discussion in the two classes will differ widely. Girls apperceive from their experiences in the household. Boys apperceive in terms of their experiences in the street, the shop or elsewhere.

Among other values that are derived from the study of science, the author believes that these are paramount. Science should teach one to pursue an idea to some ultimate conclusion. It should give one the power to express such a conclusion briefly, clearly and to the point. Science should instill habits of close observation. Not only must the pupils' conclusions be watched, but the expression of their ideas should be carefully guarded. Is it not reasonable to believe that the time for giving the child a basis for scientific expression, coincides with the time that an aptitude comes for securing the foundation for later foreign language work? Accordingly, every opportunity has been seized in this course to broaden the scientific vocabulary of the pupil. A vocabulary of the sort I have in mind and following closely new visual ideas, provides the child not only with the instruments of

accurate scientific expression, but with a vocabulary for his entire life.

Since the aim in all teaching is to make as many points of contact between the new and old ideas of pupils as possible, the work of the fourth day comprises an account of the life and achievements of some man who figured prominently in the particular phase of physics under discussion. When the "conduction of heat" experiment is under consideration, Dewar, the liquefier of refractory gases, and the inventor of the thermos bottle, appeals to the imagination of the boys and girls.

Science can be made a part of the student's mental life by making it a part of his physical life and environment. A boy or girl will never forget the principles of the first class lever or the distinction between first and second class levers if he is once taught to recognize these in a teeter-totter and wheelbarrow. Strange to relate, high school youths and maidens do forget these truths. The writer accounts for the facts in this way. The interests of grade children are principally in things while the dominant interests of high school pupils are social. Another example of what I mean by relating the principles of physics to the physical life of the child is contained in the "conduction of heat" experiment. A girl will remember the methods of transmission of heat when she thoroughly realizes that the walls of a thermos bottle are of glass because glass is a non-conductor of heat, the space between the walls is a vacuum to avoid loss of heat by convection, and the inner walls of glass are silvered to prevent radiation.

A half hour of the fifth day is consumed in the test on the four days of laboratory work, discussion, and instruction. The author has found it desirable to discuss the questions after the papers have been handed in. The test serves a number of purposes which are discussed in the succeeding paper. There are two purposes which the writer considers important from a teacher's standpoint. First, the written test shows both instructor and pupil that certain phases of the work which were thought mastered are still hazy in the student's mind. Second, it shows the teacher the weak places in his presentation. The final discussion gives the child an opportunity to gain a clearer and more definite understanding.

After two years experience, the following list of experiments has been adopted. The individual exercises are in the course principally because they seemed to be the best nuclei, upon which

to base the discussion of facts, that could be provided at a reasonable expense. It should be borne in mind that the grasp the pupil gains of the science varies inversely with the complexity of apparatus which is used to demonstrate the experiments.

The illustrations for this course were done by students in high school physics.

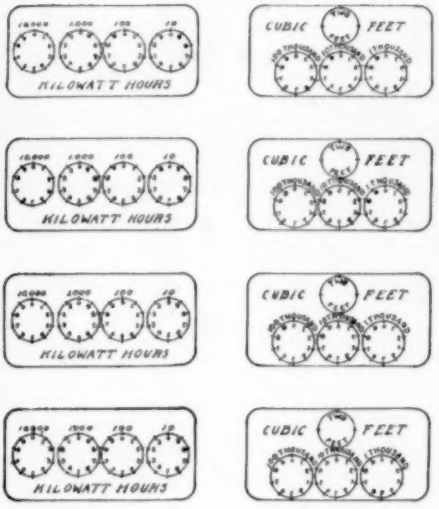
OUTLINE OF COURSE.

FIRST WEEK: WATT METER AND GAS METER. *(Exercise I, Plate I)*: This is an exercise in learning to read gas and electrical meters and to compute the cost of power. The school power and heating plant, if there is one, furnishes an abundance of material. This exercise has considerable value from the fact that it starts the class off in a spirit of enthusiastic good will toward the instructor. This field problem gives the class a large opportunity to observe many practical applications of physical laws which can be continually referred to, as occasion occurs, throughout the entire course. At the conclusion of the course the class should be given another day in the power plant. One is surprised at the increased intelligence with which the children discuss such topics as dynamo, steam engine, field magnets, etc. Electricity will no longer be known as the "juice."

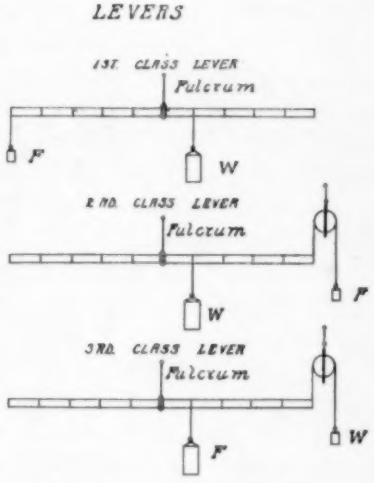
SECOND WEEK: LEVERS *(Exercise II, Plate II)*: The purpose of this experiment is to study the different kinds of levers and to familiarize the children with the parts of the lever as they are related to one another in common tools and instruments such as in the shovel, the axe, the hoe, the pump-handle, the nut-cracker, the see-saw, the wheelbarrow, the broom, a pair of scales, a sugar tongs, etc. As an exercise in either arithmetic or algebra the relation of force arm times force and of weight arm times weight is taught.

THIRD WEEK: PULLEYS *(Exercise III, Plates III and IV)*: The stress in this exercise was laid upon the relation existing between load and force in various pulley combinations without naming the relation known as mechanical advantage. The pulley idea was applied to lifting cranes and other practical uses.

FOURTH WEEK: WEIGHING *(Exercise IV, Plate V)*: The emphasis in this experiment was laid upon the correct use of the spring balance and of the beam balance. Special attention was given to the method of balancing a scales correctly. To give the exercise content the pupils were required to find the weight in grams of a pint of water and to measure its volume in cubic centimeters. From this they deduced the weight of a cubic centimeter.

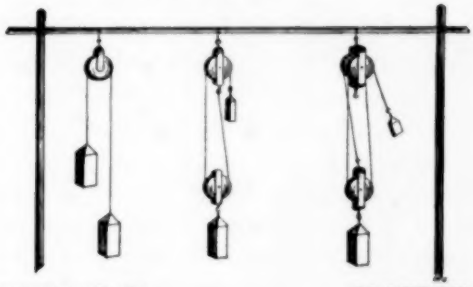


EXERCISE I PLATE I

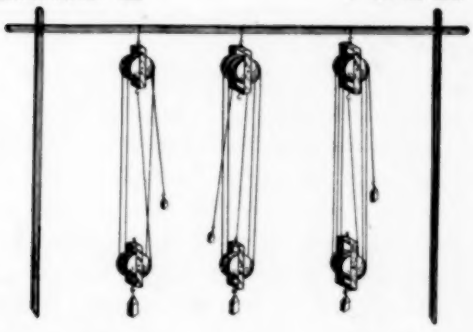


EXERCISE II PLATE II

PULLEYS



EXERCISE III PLATE III



EXERCISE III PLATE III

FIFTH WEEK: THE BUNSEN BURNER *(Exercise V, Omitted)*: In this experiment the object was to familiarize the student with the construction and proper method of care and use of the burner. In addition the children were taught the correct methods of igniting and extinguishing gas flames in general.

SIXTH WEEK: THE EFFECT OF HEAT UPON WATER (EXPANSION AND CONTRACTION OF LIQUIDS) *(Exercise VI, Plate VIII)*: The general purpose here was to acquaint the boys and girls with the phenomena of liquid expansion and the consequent transference of heat by convection. We applied the principle to expansion to thermometers, telegraph wires, steel rails, cement walks, etc.

SEVENTH WEEK: THE EFFECT OF HEAT UPON AIR (EXPANSION OF GASES) *(Exercise VII, Plate X)*: This exercise gives an excellent opportunity to introduce the subject of ventilation and allows correlation with the subject of winds in geography.

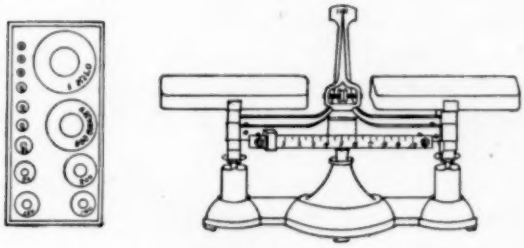
EIGHTH WEEK: CONDUCTION OF HEAT *(Exercise VIII, Plate XI)*: Here an experiment on the conductivity of three common metals, copper, brass, and iron, served as a basis for discussion of conductors and heat insulators in their relation to everyday life. Fireless cooker and thermos bottle; the reasons for a walled furnace; steam pipes wrapped with asbestos; wooden handles on cooking utensils; air spaces between the walls of houses; metallic radiators; etc., are satisfactorily explained to the ever curious boy or girl.

NINTH WEEK: MAGNETIC POLES AND THE COMPASS *(Exercise IX, Plate XII)*: This experiment introduces the pupil to the subject of magnetism and in an elementary way, he discovers the reason for a compass needle pointing as it does. In this same connection the distinction between the magnetic and geographical poles of the earth is explained.

TENTH WEEK: MAGNETIC LINES OF FORCE AND THE MAGNETIC FIELD *(Exercise X, Plate XIII)*: In this exercise, the condition of the space about a magnet is studied. An attempt is made to have the class get an idea of the relation of lines of magnetic force to the direction the compass needle takes in any part of the magnetic field. The effect of soft iron upon the direction of the lines of force can also be shown very nicely and the explanation is then forthcoming why a compass does not indicate the true north in the neighborhood of iron.

ELEVENTH WEEK: HOW TO MAKE A SAL AMMONIAC BATTERY *(Exercise XI, Plate XIV)*: The idea here was to familiarize the

TRIP SCALE AND WEIGHTS

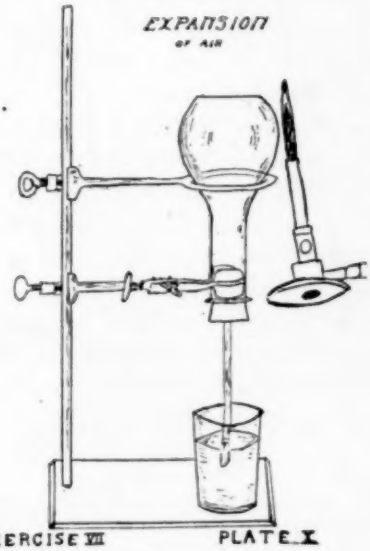


EXERCISE IV.

EXPANSION OF WATER

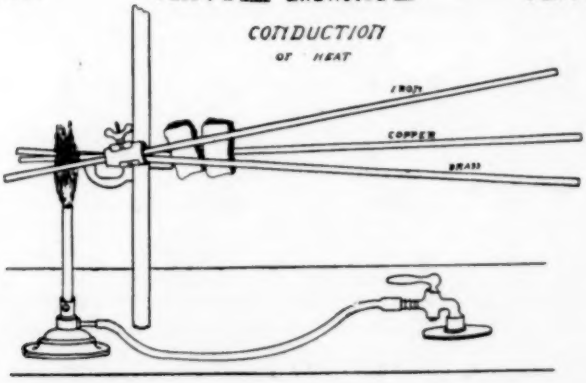
PLATE V.

EXPANSION OF AIR



EXERCISE VI PLATE VIII EXERCISE VII PLATE X

CONDUCTION OF HEAT



EXERCISE VII PLATE XI

pupils with the precautions that must be taken to get good results from the battery. It was also desired to give the children practice in handling the voltmeter and ammeter.

TWELFTH WEEK: THE ELECTROMAGNET *(Exercise XII, Plate XV)*: At this juncture, the children learn to distinguish between electric current and magnetism. At the same time, they are taught the very close interrelation of the two. The door bell, telegraph sounder, telegraph relay, telephone receiver, lifting magnet and numerous other examples make the electromagnet command the respect of the children. By this I mean that children are accustomed to think harder upon any subject for which they see a future use or a satisfaction for present curiosities.

THIRTEENTH WEEK: THE ELECTRIC DOOR BELL OR ELECTROPLATING *(Exercise XIIIA, Plate XVI)*: The aim in the last two experiments was to give the class experience with the proper care and use of the battery along with the facts to be appropriated from the experiments.

With this we conclude the course, as we use it in our schools.

School programs differ widely. What we have found to be successful under our peculiar environments and unique school program might prove an utter failure under other conditions. The author feels that this presentation will have been a success if it stimulates some of the readers to undertake the solution of their problem of adapting either their high school or grade work to the community in which they teach.

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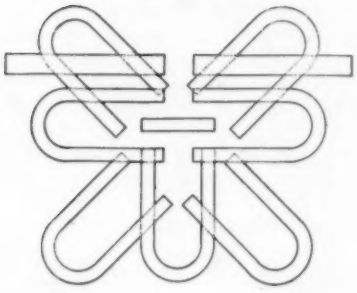
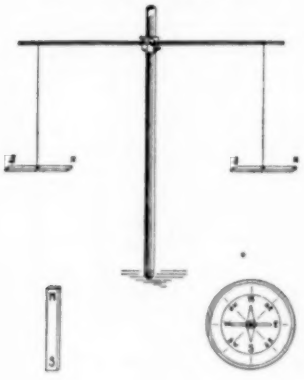
MAGNETIC FIELDS



EXERCISE X

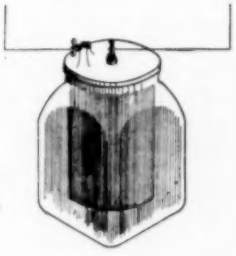
MAGNETISM (POLARITY)



EXERCISE IX PLATE XII

PLATE XIII

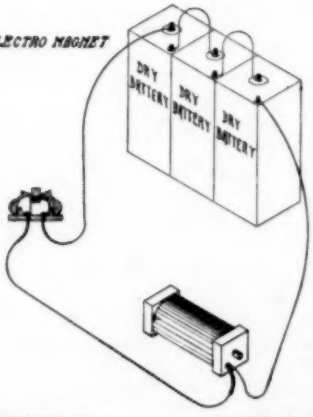
SAL AMMONIAC BATTERY

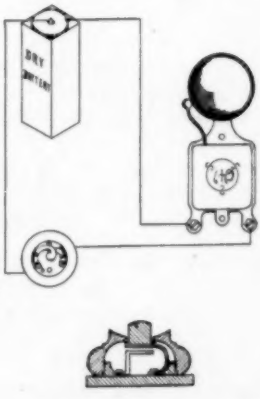


EXERCISE XI PLATE XIV

ELECTRIC DOOR BELL

ELECTRO MAGNET





EXERCISE XII PLATE XV EXERCISE XIIIA PLATE XVI

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FOREST LANDS ARE PUT TO MANY USES.

Almost every conceivable use to which land may be put is represented in the permits reported by the forest service for special projects on the national forests. Some of the uses shown range, alphabetically, from apiary through brickyard, cannery, cemetery, church, cranberry marsh, fox ranch, marine railway, rifle range, and turpentine still, to wharf and whaling station.

There are 15,000 permits in force for such special uses, which are distributed geographically from Alaska to the Mexican line, and east to Florida. This figure does not include any of the 27,000 permits in force for grazing cattle and sheep on the forests; nor the 6,000 transactions for the sale of timber, and the more than 38,000 permits issued last year for the free use of timber by settlers, miners, and others in developing their homesteads and claims; nor the nearly 300 permits for water power development.

California led all the national forest states in the number of these special use permits, followed by Arizona, Colorado, Montana, and New Mexico in the order named. The largest single class of permits was for special pastures, or corrals, to be used for lambing grounds, shearing pens, and the like. Next came rights of way for conduits, ditches, and flumes, practically all of these being free. Various agricultural permits come third, telephone lines fourth, with more than a thousand permits for 6,500 miles of line, and drift fences for the control of grazing animals, fifth. In both of these latter classes, too, practically all of the permits are free. Reservoirs for which more than 600 free permits were issued for the occupation of more than 100,000 acres come sixth. The rest of the uses are not classified though there are a large number of apiaries, camps, summer hotels, and schools. The use of the government's lands for schools is given free; for hotels a charge is made.

The principle which governs the charge is based, according to the forest service, on whether or not the use of the land is sought by the permittee for a commercial purpose. If it is the intent of the user to make money from a resource which belongs to the whole people, the service holds that he should give a reasonable return for that use. If, on the other hand, farmers want to use government land for their own telephone lines, irrigation works, and schools, the government gives them that use without cost.

A METHOD OF MAKING WALL CHARTS.

By N. A. Harvey,
State Normal College, Ypsilanti, Mich.

The following method of making wall charts, and reproductions of pictures in size suitable for class room use is probably employed by many teachers. But the conception of it was perfectly original with me when I began to use it, and it may not be so widely known or used as it might be.

A picture or map which it is desired to have for use in the class room is set up in front of a camera and a negative of lantern slide size, $3\frac{1}{4}$ by $4\frac{1}{4}$, is made from it. This lantern slide negative is then placed in the projection lantern, and projected upon a developing paper, making it of any size which it is desired to have on the walls of the room. Azo paper, 20 inches wide and in a roll ten feet long, may be bought for 80 cents. Twenty inches square is a convenient size, although 20 by 26 is also good. After the exposure is made, the paper is developed, fixed, washed and dried, when it is ready to be mounted on some good mounting board. Mounting board 22 by 28 inches is a standard size that can be procured from any paper house, or printing establishment.

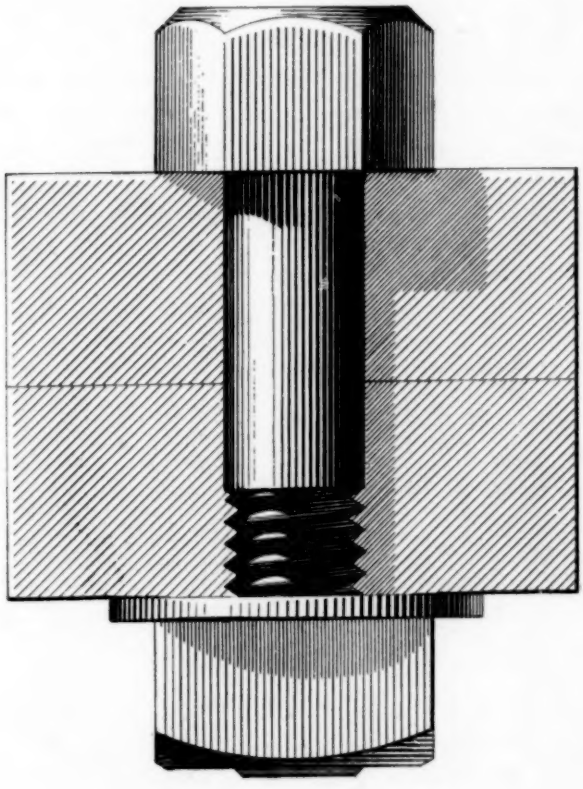
The principal difficulties in the manipulation of the method will be found in the size of the trays which it is necessary to use in developing. Wooden trays lined with oilcloth, or the insulating fabric that electricians use will be found convenient and easy to make. The amount of developer necessary is not excessive, especially if the surface of the paper in the course of developing is brushed with a camel's hair brush. The time of exposure will vary with the density of the negative and the kind of light employed. The time may vary from three seconds to one minute.

The cost of the materials necessary for making a single picture of this kind will not vary widely from 25 cents, and 30 cents will cover the cost of the making and the mounting. A good chart that can be made for 30 cents is available for every school.

In some respects and for some purposes charts are much more convenient than are lantern slides. When a teacher can make his own charts he has at his command a means of stocking up his laboratory and class room with illustrations of his own selection, which are much more serviceable than are those which are selected and published by firms who do not know exactly the conditions that prevail in the work.

A SAMPLE DRAWING.

This is a specimen drawing, containing the quality of work which we would encourage our contributors to submit when sending articles for publication, illustrated by line drawings. The figure here shown is hand work and the actual size of the original.



SLATE AND SHALE USED IN MANUFACTURE OF PAINTS AND LINOLEUMS.

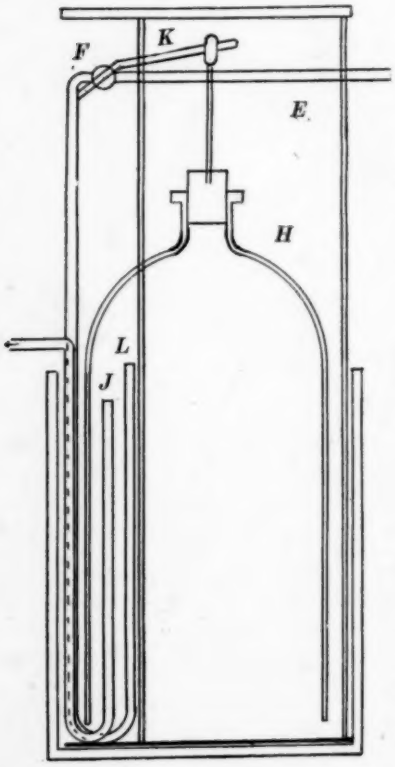
Slate and shale are used to a considerable extent in the manufacture of pigments and as fillers in the manufacture of oilcloth and linoleums, the total quantity used for this purpose in 1912, according to the United States Geological Survey, being 20,964 short tons, valued at $121,482. This was an increase of 4,454 tons in quantity and of $16,031 in value over the output for 1911. The 1912 output of slate and shale used for paints and for fillers came from Pennsylvania, New York, New Jersey, Indiana, California, and Georgia—named in the order of their production, Pennsylvania producing over 84 per cent of the total output in the United States. The shales which are used in the paint trade are classed as black, yellow, and red shales.

A PRESSURE EQUALIZER FOR AIR OR GAS.

By N. F. Smith,
Centre College, Danville, Ky.

During the progress of an investigation it became necessary to maintain a flow of air under a perfectly constant pressure. Two excellent forms of pressure regulator were devised some years ago by Edgar Stansfield, and described by him in the *Transactions of the Faraday Society*, Vol. VII, page 116. Our source of compressed air was a tank connected to a hydraulic air compressor which maintained a pressure of approximately twenty-five pounds. Neither of the forms described by Stansfield worked well under so high a pressure. The apparatus shown in the figure was therefore constructed and its behavior was entirely satisfactory.

The bottom was removed from a two and one-half litre bottle. This was placed in a battery jar about half full of water. Two "U" tubes, L and J, passed under the edge of the bottle and terminated in the air above the water. One of these tubes, J, delivered the air at constant pressure. The other, L, was connected through a glass stop-cock, F, to the air-tank. The bottle was supplied with a tight-fitting rubber stopper into which was fitted a short brass rod terminating in a ring at the top. A bent glass rod, K, connected with the stop-cock and passed through this ring. Suitable guides allowed the bottle to move up and down freely, without tipping.



It is evident from the figure that the pressure at which the air is delivered is that produced by the weight of the bottle and could be increased if desired by placing weights symmetrically around the neck. If the pressure at the source increases, the bottle

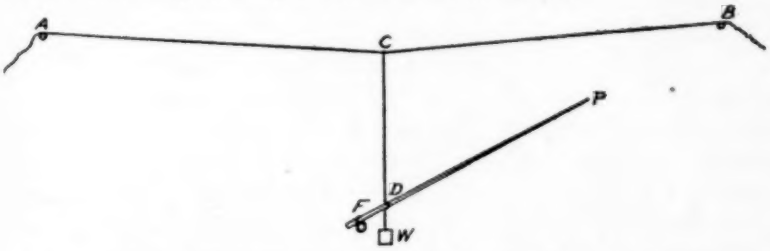
rises and partly closes the stop-cock. As the air in the bottle escapes, the bottle falls and the stop-cock opens more widely. Of course the apparatus would work equally well as a regulator of gas pressure.

HEATING EFFECT.

By Gustav Wittig,

University of Alabama, Tuscaloosa, Alabama.

The scheme shown in the accompanying sketch has been found convenient for demonstrating to a large class the heating effect of an electric current. Not the least advantageous feature is the simplicity of the equipment used. As here described the demonstration is easily seen by a class of two hundred.



AB is a fine iron wire, say No. 20 (the exact size is not important), attached to a support at each end. The farther the supports are apart, the more striking will be the result; ten feet is not too far. From a point C about the middle of the wire is hung another fine wire carrying a weight of a few grams, W. FP is a light pointer two or three feet long, attached at the end, F, to a fulcrum, while at D a loop of the wire, CW, is passed around it. The supports, A and B, should be fairly rigid; if clamp-stands are used they should be weighted at the foot. For the fulcrum, F, use a little bar mounted horizontally on a clamp-stand and attach the pointer with a wire twisted firmly around the pointer and loosely enough around the bar to allow free motion. A piece of white paper on the end of the pointer, P, makes it easier to see the motion at a distance. FD may be taken one-tenth of FP. The main wire, AB, will be too fine to be seen except by those near it; it may be outlined by paper riders.

Current sent through AB causes the end of the pointer, P, to descend. Half an ampere is enough to cause a visible movement; three amperes move the pointer through half a quadrant; if the current is made a little greater, the paper riders begin to smoke.

AN IMPULSE APPARATUS FOR THE SECOND LAW OF MOTION.

By John Mead Adams,
Queen's University, Kingston, Ont.

This apparatus is intended primarily to afford a direct test of the truth of the second law of motion in the form in which the law was stated by Newton, viz., that the rate of change of momentum is proportional to the force producing it. Incidentally, the experiment may serve to determine the acceleration of gravity, and for this purpose it is as satisfactory as any of the elementary methods for making that measurement, except those involving simple harmonic motion. The experiment is not designed to be performed by junior students, but has been developed to serve as a review of fundamental principles at the beginning of an advanced laboratory course in mechanics.

The apparatus consists of a vane of one-sixteenth inch brass plate, fifteen inches long, four inches wide at the top and two and one-half at the bottom (outlined in Figure 1), to which is soldered, near the bottom, a funnel of sheet brass two inches in diameter at the base, with a small re-entrant funnel at its mouth and with a side outlet (shown in section in Figure 2). The lugs at the upper end of the vane are filed to a sharp edge below and the vane, supported on these knife-edges, swings freely.

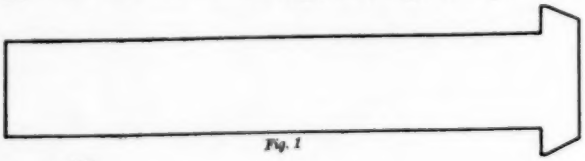


Fig. 1

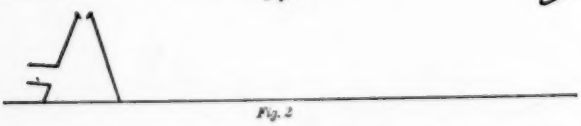


Fig. 2

A small swift stream of water is directed horizontally from a nozzle of uniform glass tube, several inches long, into the funnel. Its impact against the vane deflects the latter by an amount which can be read from a scale placed parallel to the stream and near one side of the vane, the edge being filed sharp at that place to make an index. The water is discharged downward, without horizontal momentum, through the outlet in the side of the funnel.

Knowing the diameter of the nozzle and the quantity of water discharged during a measured interval of time, both the speed of

the water and the mass stopped per second may be calculated, and hence the rate of change of momentum of the stream may be found. The corresponding force may be calculated from the equality of the two moments on the vane: the restoring moment due to gravity, and the deflecting moment due to the impact.

The constancy of the ratio, rate of change of momentum to force, verifies the law; and the mean value of that ratio measures the acceleration of gravity. The following data and results were obtained from five consecutive trials:

Weight of vane	375	gms.
Distance, knife edges to centre of gravity of vane	17.5	cms.
Distance, knife edges to centre of base of funnel	30.7	cms.
Distance, knife edges to scale	33.8	cms.
Distance, mouth of funnel to base of funnel	5.0	cms.
Zero reading on scale	20.0	cms.
Diameter of nozzle	0.240	cm.

Trials,	1	2	3	4	5	
Time	25.4	28.8	26.2	22.5	27.8	secs.
Scale reading	14.4	14.45	14.8	15.5	15.95	cms.
Weight of water discharged	993	1135	979	779	935	gms.
Mass of water stopped per second	39.1	39.3	37.4	34.6	33.6	gms.
Speed of water	862	867	826	765	742	cm. per sec.
Rate of change of momentum, $10^2\times$	337.5	341	309	265	250	gm. cm. per sec.^{2}
Tangent of angle of deflection	0.166	0.164	0.154	0.133	0.120	
Distance, knife edges to point of impact	31.5	31.5	31.5	31.4	31.3	cms.
Force of water on vane	34.7	34.1	32.1	27.8	25.3	gms. wt.
Ratio $\frac{\text{rate of change of momentum}}{\text{force}}$	972	1000	962	952	989	cms. per sec.^{2}

Mean value of the ratio, 975.

SUMMER SESSION IN GEOGRAPHY AND GEOLOGY AT CORNELL UNIVERSITY.

Any one contemplating taking summer work in any course and especially geology cannot find a better school or a more delightful spot in which to do this work than Cornell University. This school has always enjoyed the reputation of being the most beautifully situated of all the colleges in the country. Its situation for the study of the natural sciences is second to none in the United States. There are dozens of gorges within a radius of twelve miles from the campus. Some are 400 and more feet in depth. The campus is bounded both on the north and south by such gorges, each of which is easily accessible to students. These two gorges contain several waterfalls from ten to two hundred feet high.

The faculty has been well chosen and the course splendidly outlined.

Address the Director of the summer session at Ithaca, N. Y., for further information.

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Owing to an increase in other duties, Mr. E. L. Brown, who has been editor of this department for the past five years, has been obliged to resign. Under his splendid management the department has grown beyond expectation, contributions coming from all parts of the world.

We are very fortunate in being able to fill the position by the selection of Mr. I. L. Winckler, 32 Wymore Ave., Cleveland, Ohio, to whom, from this date, all correspondence relating to this department should be sent.

Mr. Winckler has long been a contributor to this work and under his guidance we feel sure there will be no abatement in interest on the part of those who desire to see this phase of mathematics teaching put on a higher plane.

Algebra.

381. *Proposed by H. E. Trefethen, Waterville, Maine.*

Find the exact cube root of $648-\sqrt{418176}$.

I. *Solution by Amy N. Trout, Mount Morris, Ill., and Niel Beardsley, Woodstock, Ill.*

Given the quadratic binomial surd $a+b\sqrt{c}$ in which a, b and c are rational and $\sqrt{c}$ is a quadratic surd. Assume that the cube root of the expression is a binomial, one term of which, or x, is rational and the other, or y, is a quadratic surd. Then

$$x+y = \sqrt[3]{a+b\sqrt{c}} \tag{1}$$

$$x-y = \sqrt[3]{a-b\sqrt{c}} \tag{2}$$

Hence
$$x^2-y^2 = \sqrt[3]{a^2-b^2c} \tag{3}$$

Since x^2-y^2 is rational, $\sqrt[3]{a^2-b^2c}$ must be rational.

Hence when the expression a^2-b^2c is a perfect cube this method may be followed.

Cubing (1)

$$x^3+3x^2y+3xy^2+y^3 = a+b\sqrt{c} \tag{4}$$

The second and fourth terms of (4) must be irrational and the first and third rational.

Then
$$3x^2y+y^3 = b\sqrt{c} \tag{5}$$

$$x^3+3xy^2 = a \tag{6}$$

Combining (3) and (6)

$$4x^3-3x\sqrt[3]{a^2-b^2c}-a = 0. \tag{7}$$

In the problem given

$$a = 648, \quad b = -1, \quad c = 418176.$$

Substituting in (7)

$$4x^3-36x-648 = 0.$$

$$\therefore \quad x = 6.$$

From (6) then
$$y = 2\sqrt{6}.$$

Hence the cube root of $648-\sqrt{418176} = 6-2\sqrt{6}$.

II. *Solution by Mabel G. Burdick, Stapleton, N. Y.*

Let $a-\sqrt{b} = \sqrt[3]{648-\sqrt{418176}}$.

Then $a^3+3ab-(3a^2+b)\sqrt{b} = 648-\sqrt{418176}$.

Since the irrational terms must be equal, $(3a^2+b)\sqrt{b} = 264\sqrt{6}$.

Whence $b = 6$ or $6k^2$, where k is a factor of 264.

That is, $(3a^2+b)\sqrt{b} = 264/k\sqrt{6k^2}$.

Substituting, $3a^2+6k^2 = 264/k$.

$a^2 = 88/k-2k^2$.

k must be integral. To make a^2 positive, k cannot be greater than 3. Then possible values of k to make a^2 a positive integer are 1, 2. If $k = 1$, a is not rational. If $k = 2$, $a = 6$, $b = 24$. These values satisfy the equation $a^3+3ab = 648$.

Therefore $\sqrt[3]{648-\sqrt{418176}} = 6-\sqrt{24}$ or $6-2\sqrt{6}$.

By factoring first, the cube root may be found by inspection.

$\sqrt[3]{648-264\sqrt{6}} = 2\sqrt[3]{81-33\sqrt{6}}$.

As above, $(3a^2+b)\sqrt{b} = 33\sqrt{6}$.

$b = 6$.

Whence, $a = 3$.

The cube root $= 2(3-\sqrt{6})$ or $6-2\sqrt{6}$.

382. *Proposed by F. Eugene Seymour, Trenton, N. J.*

Prove that if $a^2+b^2 = c^2$, then $ab(a^2-b^2) = \mathrm{M}\cdot 84$.

Solution by I. L. Winckler, Cleveland, Ohio, and the Proposer.

Since every number is of the form $3m$, $3m\pm1$, then every square is of the form $3m$, $3m+1$. Hence if neither a nor b is a multiple of 3 the sum of their squares would be of the form $3m+2$ which is not a perfect square. Hence either a or b is a multiple of 3 and $\therefore ab = m_1\cdot 3$.

Again, every number is of the form $4m$, $4m+1$, $4m+2$, and hence every square is of the form $16m$, $8m+1$, $16m+4$. Now both a and b can not be odd for then the sum of their squares would be $8m+2$ which is not a perfect square. If one is even and one is odd they can not be of the form $4m+1$, $4m+2$ for then the sum of their squares would be $8m+5$ which is not a perfect square. Hence one of them must be of the form $4m$ and hence a multiple of 4.

$\therefore ab = m_2\cdot 4$.

Again, every number is of the form $7m\pm1$, $7m\pm2$, $7m\pm3$ and hence every square is of the form $7m+1$, $7m+4$, $7m+2$. Now no two of these could represent a^2 and b^2, for their sum, which must be a perfect square, would then be of a form different from any of the three. Hence the only possibilities for a^2 and b^2 are:

$\left\{\begin{matrix}7m+1\\7m+1\end{matrix}\right\}$, $\left\{\begin{matrix}7m+4\\7m+4\end{matrix}\right\}$, $\left\{\begin{matrix}7m+2\\7m+2\end{matrix}\right\}$ for in any of these the sum reduces to one of the above three forms and is therefore a perfect square. For any of these possibilities a^2-b^2 is a multiple of 7 and $\therefore a^2-b^2 = m_3\cdot 7$.

$\therefore ab(a^2-b^2) = \mathrm{M}\cdot 84$.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

The condition $a^2+b^2 = c^2$ is fulfilled (a, b, c being integers) if $a = p^2-q^2$ and $b = 2pq$, where p and q are any integers,

because $c^2 = p^4-2p^2q^2+q^4+4p^2q^2 = (p^2+q^2)^2$.

Then $ab(a^2-b^2) =$

$2pq(p^2-q^2)(p^4-6p^2q^2+q^4)$

$= 2pq(p^2-q^2)(p^4+p^2q^2+q^4-7p^2q^2)$

$= 2pq(p^6-q^6)-14p^2q^2(p^2-q^2)$

$= 2pq(p^6-1)-2pq(q^6-1)-14p^2q^2[pq(p-1)(p+1)-pq(q+1)(q-1)]$

$$= 2pq(p+1)(p-1)(p^4+p^2+1)-2pq(q+1)(q-1)(q^4+q^2+1)-14p^2q^2[pq(p+1)(p-1)-pq(q+1)(q-1)]$$
$$= 84 \cdot M.$$

Since p^6-1 and q^6-1 are multiples of 7, and $p(p+1)(p-1)$ and $q(q+1)(q-1)$ are multiples of 3.

III. *Solution by T. M. Blakslee, Ames, Iowa.*

If a, b, c are positive integers,

$$a^2+b^2 = c^2 \text{ is } (4k)^2+(3k)^2 = (5k)^2$$
$$\therefore \quad ab(a^2-b^2) \text{ is } 4k \cdot 3k \cdot 7k = 84k^3.$$

Geometry.

383. *Proposed by W. T. Stratton, Manhattan, Kansas.*

In the triangle ABC, P is at a distance l and m from AC and AB respectively; P′ is at a distance l' and m' from AC and AB. If $l \cdot l' = m \cdot m'$; show that the angle PAC equals angle P′AB.

I. *Solution by Elmer Schuyler, Brooklyn, N. Y., and T. M. Blakslee, Ames, Iowa.*

Since $l \cdot l' = m \cdot m'$, $m : l' = l : m'$.

Hence if $\angle$BAC be rotated about the line bisecting this angle, P′ must fall upon the line AP, since $m : l' = l : m$ is the necessary and sufficient condition that a point may lie in an angle and its distances from the sides bear a fixed ratio.

II. *Solution by N. P. Pandya, Sojitra, India.*

Let PQ, P′Q′ be perpendiculars on AC, and PR, P′R′ be perpendiculars on AB.

Then the quadrilaterals AQPR, AQ′P′R′ are cyclic.

Since PQ : PR = P′R′ : P′Q′ and since $\angle P = 180^\circ - \angle A = \angle P'$, therefore triangles PQR and P′Q′R′ are similar.

$\therefore \angle PRQ = \angle P'Q'R'$. But $\angle PRQ = \angle PAC$ and $\angle P'Q'R' = \angle P'AB$.
$\therefore \angle PAC = \angle P'AB$.

III. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let $AP = \rho$, $AP' = \rho'$, $\angle PAC = \delta$ and $\angle P'AB = \delta'$.

Then we have

$$\sin\delta = \frac{l}{\rho}, \ \sin(A-\delta) = \frac{m}{\rho}$$
$$\sin\delta' = \frac{m'}{\rho'}, \ \sin(A-\delta') = \frac{l'}{\rho'}$$

Whence

$$\frac{\sin\delta}{\sin(A-\delta)} = \frac{l}{m} \text{ and } \frac{\sin\delta'}{\sin(A-\delta')} = \frac{m'}{l'}$$

Since $l \cdot l' = m \cdot m'$

$$\frac{\sin\delta}{\sin(A-\delta)} = \frac{\sin\delta'}{\sin(A-\delta')}$$

or
$$\sin\delta\cos\delta' - \sin\delta'\cos\delta = 0.$$
$$\sin(\delta-\delta') = 0.$$
$$\therefore \ \delta = \delta'.$$

NOTE: Rays PA and P′A are isogonal conjugate with respect to $\angle$BAC.

384. *Proposed by A. Heinz, Peking, China.*

Find the length of a line parallel to the bases of a trapezoid in terms of

the bases, the ratio of the segments into which non-parallel sides are divided being known.

Solution by W. M. Gaylor, Sag Harbor, N. Y., and Mary W. Clark, Little Falls, Minn.

Let a, b be the bases, $m : n$ the given ratio, and l the line $\|$ to a or b, whose length is required to be found.

The heights of the trapezoids (a, l), (l, b) are mx and nx respectively, so that the height of the whole trapezoid is $(m+n)x$.

$\therefore$ the relation between twice their areas is

$$(a+b)(m+n)x = (a+l)mx+(l+b)nx.$$
$$\therefore (a+b)(m+n) = (a+l)m+(b+l)n.$$
$$\therefore an+bm = l(m+n).$$
$$\therefore l = \frac{an+bm}{m+n}$$

385. *Proposed by A. Heinz, Peking, China.*

Prove: In a truncated prism having a regular polygon of n sides as a cross section, the line passing through the center of this polygon, parallel to an edge and joining the non-parallel bases, is equal in length to the average of the n edges of the truncated prism, from this show that the volume of any truncated prism with regular polygon as cross section is product of area of cross section into length of this centre line.

Solution by Nelson L. Roray, Metuchen, N. J.

Given a truncated *right* prism whose base is a regular n-gon.

To Prove: First, the sect perpendicular to the base at its mid-point with its other end point in the section is the average of the edges of the prism.

Proof: Let ABCDE . . . be the base of the prism, A'B'C'D'E' . . . the section, a, b, c, d, e . . . the edges of the truncated prism, r radius of base, s side of base and h the required sect, and n number of sides of polygon.

(a) Suppose the base has an *even* number of sides, then if A and M are a pair of opposite vertices AMM'A' is a trapezoid with h its median;

$$\therefore h = \tfrac{1}{2}(a+m)$$

Similarly for other pairs of vertices.

$$\therefore h = \frac{a+b+c+d+ \ . \ . \ .}{n}$$

(b) If the base has an *odd* number of sides, the perpendicular from any vertex to the side opposite passes through the center of the polygon and is divided at this point in the ratio

$$\frac{2r}{\sqrt{4r^2-s^2}}.$$

In this case by problem No. 384.

$$h = \frac{a\sqrt{4r^2-s^2}+r(m+l)}{2r+\sqrt{4r^2-s^2}}$$

Similarly for each vertex and its opposite side.

$$\therefore nh = \frac{(a+b+c+ \ . \ . \ .)\sqrt{4r^2-s^2}+2r(a+b+c+ \ . \ . \ .)}{\sqrt{4r^2-s^2}+2r}$$

$$\therefore h = \frac{a+b+c+ \ . \ . \ .}{n}.$$

Second. The volume of the truncated prism is equal to the area of the base multiplied by h.

Let the truncated prism be divided into triangular truncated prisms with the common edge h and bases the triangles whose common vertex is center of polygon and bases sides of the polygon.

Denote area of each of these triangles by S'.
Then volume of each triangular truncated prism is

$$\frac{S'(h+a+b)}{3}.$$

Volume of truncated prism

$$= \frac{S'(h+a+b)}{3} + \frac{S'(h+b+c)}{3} + \ldots \frac{S'(h+z+a)}{3}$$

$$= S'\left[\frac{nh}{3} + \frac{2}{3}(a+b+c+\ldots)\right]$$

$$= S'\left[\frac{nh}{3} + \frac{2}{3}\cdot nh\right]$$

$$= (nS')h$$

$$= \text{Area of base} \times h.$$

The above is for a right truncated prism with regular polygon for base. If prism is not right but one whose right section is a regular polygon, merely consider the truncated prism as composed of two right truncated prisms whose bases are the right section, apply the above theorem and by adding get result desired at once.

CREDIT FOR SOLUTIONS.

376. Elizabeth Sargent, George Y. Sosnow. (2)

377. Viola M. Blaisdell. (1)

379. Veda B. Larson. (1)

380. Veda B. Larson, George Y. Sosnow. (2)

381. Niel Beardsley, E. G. Berger, T. M. Blakslee, Hugo Brandt, Mabel G. Burdick, Walter C. Eells, A. M. Harding, Henry A. Levy, N. P. Pandya, Nelson L. Roray, F. Eugene Seymour, Elmer Schuyler, Levi S. Shively, Amy N. Trout, I. L. Winckler, Edwin Wood. (16)

382. Hugo Brandt, T. M. Blakslee, Walter C. Eells, N. P. Pandya, Nelson L. Roray, F. Eugene Seymour, Levi S. Shively, I. L. Winckler, Edwin Wood. (9)

383. Hugo Brandt, T. M. Blakslee, Harold Britton, Mabel G. Burdick, Max Odnos, N. P. Pandya, Nelson L. Roray, Elizabeth Sargent, Elmer Schuyler, F. Eugene Seymour, George Y. Sosnow, I. L. Winckler. (12)

384. Niel Beardsley, S. Birnbaum, T. M. Blakslee, Hugo Brandt, Mabel G. Burdick, Mary W. Clark, W. M. Gaylor, Veda B. Larson, N. P. Pandya, Nelson L. Roray, F. Eugene Seymour, I. L. Winckler. (12)

385. Hugo Brandt, W. M. Gaylor, N. P. Pandya, Nelson L. Roray, I. L. Winckler. (5)

Total number of solutions, 60.

PROBLEMS FOR SOLUTION.

Algebra.

396. *Selected.*

If p is a positive integer, show:

(a) that $p(p+1)(p-1)$ is a multiple of 6;

(b) that p^6-1 is a multiple of 7.

397. *Proposed by Niel Beardsley, Woodstock, Ill.*

Solve:

$$x^4-y^4 = x^2+y^2. \quad (1)$$

$$x^3+y^3 = xy. \quad (2)$$

Geometry.

398. *Proposed by Grace E. Shoe, Denver, Colorado.*

Construct a triangle, having given one side, the circum radius and the inradius.

399. *Proposed by Norman Anning, Chilliwack, B. C.*

A man travels directly eastward 25 miles per hour. Find the latitude if his days are 23 hr. 15 min. long., supposing that the earth is a sphere of radius 3960 miles.

400. *Proposed by Hugo Brandt, Boston, Mass.*

Inside of a box with a rectangular base 32″ by 16″ and vertical walls 18″ high, take a point A in the vertical center line of one of the 16″ by 18″ walls, 4″ above the base. On the opposite wall, in its vertical center line, take three points, B, C, D, whose distances above the base are 12″, 13″, 14″, respectively. Find shortest distance from A to each of the points B, C, D, the path to be on inner surface of the box.

ONTARIO EDUCATIONAL ASSOCIATION.

The annual meeting of the Mathematical and Physical Section of the Ontario Educational Association was held in Room 8, University of Toronto Buildings, on April 14th and 15th.

The following program was carried out:

Tuesday, April 14th.

1. Registration of members.
2. Reading of minutes, etc.
3. President's address, "Avocations of Mathematicians," T. A. Kirkconnell, M. A.
4. "Ratio and Proportion," Prof. Findlay, McMaster University.
5. "On the Relative Importance of Propositions, Principles, and Exercises in Algebra, with Application to Examination Papers," R. N. Merritt, B. A.

Wednesday, April 15th.

1. "The Physical Universe and the Ancients," Prof. Buchanan, Queen's University.
2. "Some Experiences as a Scholar and Teacher," I. J. Birchard, Ph. D.
3. "Alternative Solutions," E. J. Wethey, M. A.
4. Election of Officers, resulting as follows: Hon.-Pres., I. A. Kirkconnell; Pres., A. M. Overholt; Vice-Pres., R. Wightman; Secy.-Treas., W. J. Longheed; Councilors: W. L. Sprung, G. F. Armstrong, T. Kennedy, R. Gourlay and W. R. Bocking.

H. S. R.

PHYSICAL SCIENCE CLUB.

Saturday, April 18th, the science teachers of eastern New York met at Schenectady and organized "The Physical Science Club of the Capital District." The morning was spent in a trip through the plant of the General Electric Co. In the afternoon the teachers met at the high school and after inspecting the equipment, the organization of the club was perfected and plans for future meetings were discussed.

It is hoped that at the next meeting, which is to be held at Schenectady, May 23rd, all of the physics and chemistry teachers of eastern New York will be present for a discussion of the state syllabus. The following officers were chosen:

President—C. F. Hale, Albany Normal College.
Vice-President—E. O. Hoffman, Schenectady High School.
Secretary-Treasurer—R. E. Abbey, Schenectady High School.

LIVE CHEMISTRY.

By H. R. Smith,
Lake View High School, Chicago.

In all new movements, like the present one of vocational education, there are those who would abandon the tried methods of the past to take up the new. Then, there are others who are skeptical of the value of new methods and decry them. There is evidence at the present time of the formation of these two classes on the subject of vocational education.

In so far as these articles dealing with experimental chemistry go, we may say that we cannot abandon the manuals now in use, even if we wish, for there are no others of vocational type to supplant the present books. We are trying to develop that field and determine its values.

One explanation of the readiness with which vocational education is advocated is that education has become too formal and too remote from the real interests of men and women to be efficiently educational. If teachers, as a class, were more progressive and *evolutionary* there would be no need of *revolutions* of method.

There is one thing certain at this stage of the committee's work, and it is very significant. It has been demonstrated by various teachers that laboratory work dealing with a real problem of life awakens in the student an amount of interest many times greater than that by experiments designed to exemplify some parts of a text-book. This appeal to the interest must be looked upon as of great value educationally, for the invariable result is that the students repeat, of *their own accord* the experiment in different phases, and extend its applications in various ways. The chemical principles embodied in the experiment are learned thoroughly in this way, and in a natural way for the student. The average teacher by reason of his training insists on presenting theory first, then proving by experiment, and lastly applying to life. The teacher should remember that he is instructing young people, and that he should not use the methods of his college professor. The high school youth, and in fact all of us when we are ourselves naturally, when some new thing comes to notice, inquire first, "What is it for?" Then "How does it work?" and if it touches personal interest sufficiently the details of the whole operation are studied out. When the need of knowledge is apparent to the student his mind becomes more receptive, and his efforts know no limit until mastery of the subject is complete. Our present method of approach in laboratory work is at fault in that the above need is not made plain at the outset. Experiments published in previous numbers of this journal have been found free from this fault. Crudities are to be found in them it is expected, since as a whole they have not been thoroughly perfected. Again we ask teachers of chemistry to write us giving advice and criticism with any experiments of similar nature that they may have worked out.

The following quantitative experiment on analysis of union goods is now used by some teachers. It should be used by all. A Lake View student learned at a Chicago department store that "all wool" may mean only 80 per cent wool. Then, there is the "strictly all wool," about 90 per cent, while the "absolutely all wool" is the really *all* wool. The public should know these tricks of the trade.

The experiment on photosynthesis is unique in using a leaf separate from the plant To our knowledge no one has proposed this plan before. The samples of work show that the method can give good results.

The experiment on supersaturation requires some previous knowledge

for the interpretation of results. Its use will afford much interest for this topic.

Correction is given for the experiment on "silvered mirrors" in the April issue. It should read "boil solution C" instead of solution B.

To Determine the Per Cent of Cotton and Wool in Union Goods.

Wool and silk (animal fibers) are quite different chemically from cotton and linen (vegetable fibers). Cotton is cellulose and made up of the three elements—carbon, hydrogen, and oxygen—while wool is protein and has in it, besides carbon, hydrogen and oxygen, about 16 per cent of nitrogen. This difference in composition accounts for the great difference in chemical behavior. Cotton is able to withstand alkalies but even strong soap, a very mild base, will affect wool, causing its fiber to be injured and the cloth to shrink. On the other hand, wool withstands the action of most acids but cotton fiber is destroyed by them.

So-called woolen goods is only too often very largely cotton, the mixture being cheaper and very inferior to a fabric of wool. The per cent of cotton in mixed goods may be determined by an experiment which is based on the fact that wool is dissolved in alkalies. Weigh, accurately, about 5 g. of the sample and boil for ten minutes in a 5 per cent solution of potassium hydroxide, then wash well with water first and with a .5 per cent solution of acetic acid. Dry thoroughly and weigh. Record your results as:

Weight of sample .....
Weight of residue (cotton) .....
Loss of weight (wool) .....
Per cent of cotton .....
Per cent of wool .....

The cotton suffers some loss in the alkali. Your result should be corrected by adding 5 per cent to the determined per cent of cotton and subtracting 5 per cent from the per cent of the wool.

This is a very instructive experiment. It is not hard to find cloth in which about half the threads are cotton. It may be rather hard to obtain accurate results but it will not be uninstructive even if it is not quantitative. It is proposed by Dr. J. Merritt Mathews.

Thos. R. Moyle,
Stout Institute, Menomonie, Wis.

Photosynthesis.

This is an experiment to show that carbon dioxide and water in the presence of chlorophyl and sunlight change into starch. Cut a stencil out of tinfoil, black paper, or cardboard. Place this stencil in a printing frame, next to it a geranium leaf, and then a piece of wet blotting paper. Fasten all in position so that only that portion of the leaf shown by the stencil will be exposed to light. Place in a south window for one day (two or three days if cloudy). Remove leaf and boil five minutes in water. Place in a beaker of alcohol and heat over a water bath until most of the color is out. Use fresh alcohol and heat again until all the green is out of the leaf. Then wash the leaf in cold water; pour over it a little of a solution of iodine dissolved in potassium iodide. The stencil will show dark blue. Soak the leaf in water for about 10 minutes and press between newspapers.

Deborah Anderson (*Botany*),
West High School, Minneapolis, Minn.

Supersaturation.

Into an evaporating dish put four spoonfuls of sugar and one of water. Mix with a glass rod and heat gently, without stirring, until a drop from the end of the rod "spins a thread" one inch long. Cool thoroughly.

There should be *no sign of crystals* and the mass should be soft enough so that the finger can easily make an impression on its surface. Stir and the result should be a "fine" fondant. Where in the experiment is there supersaturation? How do you know? The fondant may be flavored or colored.

JESSIE F. CAPLIN.

PHYSICAL EFFECT OF LIME ON CLAY SOILS.

Air slaked lime, when added to clay soils, flocculates or cements the fine particles of the clay together, thus making larger or compound particles. This process transforms the fine grained clay soil into a coarser structured soil, with more of the desirable crumb or granular structure. To show the effect of lime in producing flocculation of clay, proceed as follows:

1. Prepare some turbid clay water by stirring vigorously about a teaspoonful of fine clay in a glass of pure water.
2. Allow to settle for about ten minutes, then pour off most of the turbid water into a clean dish.
3. Stir and measure out two equal portions of 80 cc. each of turbid water into long narrow graduated cylinders.
4. To one portion add about 2 cc. of lime water, leaving the second portion untreated.
5. Stir the contents of both tubes and set them aside to settle.
6. Carefully observe what takes place in both cylinders.

The reason for the clearing up of the contents of one cylinder and not of the other is that the particles are made larger and settle to bottom.

References: Lyon & Tippin, *Soils,* p. 352; Burkett, *Soils,* Chap. II; Snyder, *Soils and Fertilizers,* Chap. IX.

PROF. R. E. SMITH,
Agronomy Department, Iowa State College, Ames.

A STUDY OF THE CHANGING OF ORGANIC MATTER INTO AMMONIA.

Organic matter such as dried blood or manure, when added to the soil, undergoes a change in which the nitrogen contained in it is transformed into ammonia. This is one of the steps by which manure, when added to the soil, is changed into a plant food.

Method:

1. Weigh out 100 gms. of soil taken from a field and place it in a glass tumbler, marking it No. 1.
2. Weigh out 100 gms. of soil which has been sterilized by heating in an oven at 150° C. for a half hour or 20 minutes in an evaporating dish in the hottest burner flame. Place this soil in a glass tumbler marking it No. 2.
3. Weigh out two 5 gm. samples of dried blood and mix thoroughly with each tumbler of soil.
4. Pour 24 cc. of sterile water into each tumbler and cover the tumblers with metal or glass covers. Sterilize water by boiling for five minutes.
5. Set the tumblers in a warm, dark place for one week and then notice the strong odor of ammonia which comes from tumbler No. 1 when the cover is raised. Do you notice any ammonia being given off from tumbler No. 2?

Write complete notes upon this experiment showing how the dried blood has been changed to ammonia and why you could not get the odor of it from No. 2.

Reference: Lipman, *Bacteria in Relation to Country Life,* pp. 318-325.

PROF. R. E. SMITH,
Agronomy Department, Iowa State College, Ames.

AN INTERESTING EXPERIMENT WITH SILVER.

An experiment we have found most students to take interest in is described in some of the first year texts. We have modified the experiment to some extent to give it an added human interest. A ten cent or twenty-five cent silver coin is dissolved in dilute nitric acid and the silver is precipitated as chloride with hydrochloric acid. It is filtered and dried in an oven. The chloride is then placed in a porcelain crucible and heated to fusion. When cool, a few pieces of granulated zinc are placed on top of the melt, and hydrochloric acid is added. This loosens the lump from the crucible and effects a partial reduction to metallic silver. The mass is then removed to a piece of charcoal, and further reduced with the blast lamp and by the use of borax to a shining ball of pure metallic silver. By exercising ordinary care, there will be no loss, and a quantitative result in silver is obtained. Many of the students take their bead of pure silver to the jeweler who fuses in a stickpin for twenty-five cents, and they have a handsome article of jewelry, and a souvenir of their student days which may last a life time. The various changes in the coin up to the last operation never fail to awaken interest.

NICHOLAS KNIGHT, *Cornell College.*

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany for March; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $4.00 per year, 50 cents a copy:* "Problems and Progress in Plant Pathology," L. R. Jones; "Some Observations on the Anatomy and Other Features of the 'Black Knot,'" Alban Stewart; "Cleavage in Didymium Melanospermum (Pers) MacBr," R. A. Harper.

American Mathematical Monthly for April; *5548 Kenwood Ave., Chicago, Ill.; $2.00 per year:* "A Note on Plane Kinematics," Alexander Ziwet and Peter Field; "Note on Certain Algebraic Equations," H. L. Slobin; "A Plea for less Formal Work in Mathematics," F. M. Morgan.

American Naturalist for May; *Garrison, N. Y.; $4.00 per year, 40 cents a copy:* "Ectoparasites of Mammals," Vernon Lyman Kellogg; "Regeneration, Variation and Correlation in Thyone," John W. Scott; "Shorter Articles and Discussion; Terms Relating to Generic Types," Dr. O. F. Cook; "Notes and Literature: Linkage in the Silkworm Moth," A. H. Sturtevant; "Nabours's Breeding Experiments with Grasshoppers," John S. Dexter.

Journal of Geography for May; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Geographic Control of Transportation in the Southeast," John E. Smith; "The Vocational Aspect of Regional Geography," W. J. Sutherland; "Notes on the Ohio and Mississippi Valley Floods," R. De C. Ward; "Observations in Porto Rico," Arthur D. Cromwell; "Teaching Seasons Without Globes," Joseph F. Morse; "Preparation of Salt in China," Walter N. Lacy; "Add a Day or Drop a Day?" Charles Stratton.

L'Enseignement Mathématique for March; *Stechert & Co., West 25th Street, New York; 15 francs per year, 3 francs per copy:* L'intégrale de Stieltjes et sa généralisation," W. H. Young; "Le bicentenaire de la loi des grands nombres," A. Vassilief; "Sur l'opération 'Transport de segments rectilignes' dans les constructions de la Géométrie descriptive," G. Loria; "La ligne de terre et le second bissecteur. Notes sur certains principes de la Géométrie descriptive," C. Halphen; "Un problème se résolvant par la Géométrie à 4 dimensions," J. Sauter et F. Trosset.

Mathematical Gazette for March; *G. Bell & Sons, Portugal St., Kingsway, London; six no., 9s. per year, 2s. 6d. a copy:* The Annual Meeting, Jan. 7, 1914. "Presidential Address: The Use of Mathematics," Sir George Greenhill; "Discussion on the Syllabus." Addresses: "The Various Uses of Graphs," G. St. L. Carson; "On the Setting Out of Certain Easy Cubics," R. W. K. Edwards; "On Practical Mathematics in Schools," Prof. J. E. A. Steggall.

National Geographic Magazine for April; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "Castles in the Air. Experiences and Journeys in Unknown Bhutan," John Claude White (67 illustrations).

Physical Review for April; *Ithaca, N. Y.; $6.00 per year; 60 cents a copy:* "Some New Diffraction Photographs," Mason E. Hufford; "The Principle of Similitude," Richard C. Tolman; "Certain Experiments in Sound Diffraction," G. W. Stewart and Harold Stiles; "Polarization in the Aluminium Rectifier," Clarence W. Greene; "A Complete Collection of Thermodynamic Formulas," P. W. Bridgman; "A Study of the Propagation and Interception of Energy in Wireless Telegraphy," Charles A. Culver; "On the Continued Appearance of Gases in Vacuum Tubes," George Winchester; "The Magnetic Susceptibility of Water," H. C. Hayes; "The Effect of Magnetization on the Opacity of Iron to Rontgen Rays," A. H. Forman.

Popular Astronomy for May; *Northfield, Minn.; $3.50 per year, 15 cents a copy:* "Astronomical Panoramic Views from a City Observatory," William F. Rigge; "Relations Between the Spectra and Other Characteristics of the Stars," Henry N. Russell; "Monthly Report on Mars, No. 5," William H. Pickering.

Popular Science Monthly for May; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "The Measurement of Environic Factors and Their Biologic Effects," Dr. D. T. MacDougal; "The Theory of Relativity and the New Mechanics," William Marshall; "The Small College and Its President," One of Its Professors; "Labor and Capital," John J. Stevenson; "The Struggle for Equality in the United States," Charles F. Emerick; "Science in Newspapers," Dr. J. A. Udden; "The Science of History," Clarence Walworth Alvord; "The Practical Necessity of School Clinics," Dr. E. H. Lewinski-Corwin; "The Laboratory of Comparative Pathology of the Zoölogical Society of Philadelphia," Dr. R. W. Shufeldt.

School Review for May; *University of Chicago Press, Chicago; $1.50 per year, 20 cents a copy:* "A Plan for the Reorganization of the American Public High School," Henry E. Brown; "The Plague of Personality," William McAndrew; "The Teaching of Ideals," James H. Tufts; "The Teaching of Ideals," Ralph Barton Perry.

School World for April; *Macmillan and Company, London; 7s. 6d. per year, 6p. a copy:* "An Educational Clearing House"; "Homework in Secondary Schools," P. Shaw Jeffrey; "The Educational Value of the Kinematograph," J. W. Gregory; "The Teaching of Science," Stuart Blofeld; "The Medical Side of National Education in 1912"; "The Glasgow Conference on the Kinematograph in Education."

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 2; *Otto Salle, Berlin, W. 57, Germany; M. 4.—per year, 60 Pf. per copy:* "Die Berücksichtigung der politischen Arithmetik im mathematischen Unterricht und ihre Bedeutung für die staatsbürgerliche Bildung und Erziehung," Dr. Ph. Lötzbeyer; "Geometrische Interpretation algebraischer Sätze," Prof. Ernst Sós; "Maclaurinsche Reihe und Schmiegungsparabeln," Prof. Dane; "Stereographische Lösung einer geographischen Aufgabe aus der sphärischen Trigonometrie," Dr. Fritz Thaer; "Zur graphischen Lösung von Gleichungen durch den Schnitt von Kurven (Bibliographie der älteren Literatur zur graphischen Auflösungen durch den Schnitt von Kurven)," Prof. H. Wieleitner.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht Aller Schulgattungen for April; *B. G. Teubner, Leipzig, Germany; 12 numbers, M. 12.—per year:* "Das Gesetz von freien Falle in der Scholastik, bei Descartes und Galilei," Prof. Dr. H. Wieleitner; "Wie kann man im Experimentalunterrichte in der Physik die Schüler zum Gebrauch der Messgerate heranziehen?" Oberl. Prof. August Pauser; "Kurventheoretisches im Unterricht," Dr. Ph. Schwarz; "Ein arabisches Gefäss, dass sich stetig mit Wasser füllt und dann plötzlich ausgiesst," Prof. Dr. Eilhard Wiedermann.

REPORT OF THE TENTH ANNUAL SESSION OF THE ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

The Association of Ohio Teachers of Mathematics and Science held its tenth annual meeting at Ohio State University, Columbus, Ohio, Friday evening and Saturday, April 3rd and 4th. The State University kindly tendered the association the use of its campus and buildings. And by way of promoting acquaintance, an informal dinner had been arranged by the Vice President, Prof. S. E. Rasor, at the Ohio Union for 6:30 Friday evening, in which about forty members participated and at which the speakers of the evening were the guests of the association.

At 8 o'clock Friday evening in the auditorium of Physics Hall, Prof. Aug. F. Foerste of Dayton, who kindly consented to take the place left vacant by the death of the President, Mr. Ralph W. Buck, greeted the association and introduced Prof. Edward Orton, Jr., Dean of the College of Engineering, who gave the address of welcome in behalf of the University. This was followed by an address on "Recent Tendencies in Vocational Education," by James F. Barker, Principal of East Technical High School, Cleveland, Ohio. Mr. Barker's work in building up a large technical high school in a city like Cleveland has afforded him an unusual opportunity to study the question of technical training in its various phases; and the careful and sane way in which these problems have been worked out, in their effect on student, teacher and community at large, made the address one of the most valuable features of the meeting.

On Saturday, April 4th, at 9:00 a. m. the association convened in Chemistry Hall for general session. A few items of business received attention, and the following committees were appointed:

COMMITTEE ON NOMINATIONS.

Chas. T. Prose, High School, Zanesville, O.
W. B. Skimming, East High School, Columbus, Ohio.
Prof. Frank E. Miller, Otterbein University, Westerville, Ohio.

COMMITTEE ON RESOLUTIONS.

J. C. Boldt, Stivers Manual Training High School, Dayton, O.
Prof. K. D. Swartzel, Ohio State University, Columbus, O.

AUDITING COMMITTEE.

Prof. W. D. Cairns, Oberlin College, Oberlin, O.
Chalmers M. Parker, High School, Newark, Ohio.

The association then listened to an address on "Recent Progress in Secondary Agricultural Education," by Prof. B. M. Davis, Miami Normal College, Oxford, O. Among other phases of the subject Prof. Davis has made a careful study of recent legislation in some forty-three states, along the line of agricultural education, and his address was both valuable and interesting. The various sections then adjourned to their respective programs, as follows:

SCIENCE SECTION.

1. Some Phases of the Food Supply Problem—Prof. J. F. Lyman, Ohio State University, Columbus.
2. Elimination of Waste in High School Chemistry—Albert J. Schantz, Steele High School, Dayton, O.
3. Discussion, Experiments and Demonstrations.

PHYSICS AND CHEMISTRY SECTION.

1. Should any Stress be Placed on the Electron Theory in a First Course in Physics?—Chas. H. Lake, Principal of Hamilton, O., High School.

2. Some Difficulties Encountered in Teaching Freshman Chemistry—Prof. W. H. Whitcomb, Miami University, Oxford, O.
3. Discussion.
4. Round Table.

BIOLOGY AND EARTH SCIENCE SECTION.

1. The Possibilities of High School Physiology—Prof. R. J. Seymour, Ohio State University, Columbus.
2. Biology in the High School—Maud Flynn, South High School, Columbus, O.
3. The Daily Weather Map—Prof. J. Warren Smith, Director of Columbus Weather Bureau.

MATHEMATICS.

Morning Session.

1. Some Observations on the Teaching and Study of Mathematics in Germany—Prof. G. N. Armstrong, Ohio Wesleyan University, Delaware, Ohio.
2. The Next Step Forward—Prof. H. E. Slaught, University of Chicago.
3. Discussion—Led by W. B. Skimming, East High School, Columbus—J. C. Boldt, Stivers Manual Training High School, Dayton, O.

Afternoon Session.

1. What are We Going to Do About It?—E. Marie Gugle, Scott High School, Toledo, O.
2. The Teaching of Algebra in High School and College—Prof. A. E. Young, Miami University, Oxford, O.
3. Discussion—Led by Prof. W. D. Cairns, Oberlin College, Oberlin, O. —Chas. T. Moore, South High School, Columbus, O.

At 12:30, through the courtesy of the University, the members of the association were tendered a complimentary luncheon at the Ohio University. This contributed a very pleasant feature to the meeting and was enjoyed by some one hundred members in attendance.

At the meeting of the Science Section, Prof. Foerste presided. Mr. Albert Schantz of Dayton was unable to be present and in his place Mr. Foerste gave a very interesting talk on "Prominency of Continents and Ocean Basins." He also exhibited later some interesting apparatus to illustrate the electron theory.

In the Mathematics Section unusual interest was manifested. The attendance of the morning reached seventy, and that of the afternoon was nearly as large. Prof. S. E. Rasor, of Ohio State University, presided at both sessions.

Prof. G. N. Armstrong has recently returned from two years of life and study in Germany and his "Observations on the Teaching and Study of Mathematics" there gave many side-lights on the work of the German schools, and emphasized many points of strength in the German teaching. One particularly interesting feature of his paper was extracts from letters of German friends giving something of the personal history of their own mathematical training. The paper was most interesting and suggestive.

The address of Prof. A. E. Young was an appeal for the teaching of algebra as a science—a plea for a better, more scholarly interpretation and teaching of the fundamental principles of algebra. The address was direct, and practical, and the discussion later by Prof. Cairns and Mr. C. T. Moore most helpful.

Miss Marie Gugle, of Scott High School, Toledo, addressed the meeting on the subject, "What are We Going to Do About It?" and gave as a

possible solution the six year high school following the six years of grade work. Miss Gugle is ably qualified to speak on this subject both by reason of recent study and by wide experience as a teacher where she stimulates interest both in class room and through various other ways such as the High School Mathematics Club.

The association was exceptionally fortunate in having among its speakers Prof. H. E. Slaught of the University of Chicago. Prof. Slaught is too well known to mathematics students and teachers for it to be necessary to add that he gave stimulus and inspiration to the entire meeting. In his address, he gave first some very illuminating remarks on the character, content, and remarkable distribution of the geometry report and concluded with some discussion of the desirability for the teacher to be working along lines outside the daily routine. He suggested various lines of reading and study within the range of high school and college teachers, such books as *Fundamental Concepts of Algebra and Geometry* by J. W. Young and *Mathematical Monographs* by J. W. A. Young in collaboration with other mathematicians. In current literature and periodicals SCHOOL SCIENCE AND MATHEMATICS and *The American Mathematical Monthly* are contributing along these lines and should be in the hands of every teacher.

Concluding, Prof. Slaught said the papers of the meeting had dealt with three things:

I. Pedagogical Schemes.
II. Administrative Plans.
III. Preparation of Teachers.

The first has received in the past its share of attention and the second needs consideration, but for mathematics to maintain the place which it should in the educational system of today the preparation of teachers must claim our thought and interest. The discussion of this paper by Mr. Skimming was both profitable and suggestive; he mentioned work in constructional geometry as helpful and stimulating to the geometry teacher.

The Committee on Resolutions offered the following report:

Since our last meeting, death has removed from our midst our honored president, Mr. Ralph W. Buck. Mr. Buck was always a most enthusiastic supporter of the meetings of this association and was intensely interested in everything that pertained to the improvement of the teaching profession. He was himself an ideal teacher, a wise counsellor, and an invaluable friend.

Therefore, Resolved, That in his death this association has lost a most valuable member, the teaching profession an earnest, conscientious, and tireless worker, and each one of us an inspiring friend.

Resolved further, That this association extend to his family its sincerest sympathy and condolence in their bereavement.

Be it further Resolved, That a copy of these resolutions be spread as a permanent record on the minutes of this association and that a copy be sent to the family.

J. C. BOLDT,
K. D. SWARTZEL,
Committee.

An expression of thanks was tendered Prof. Slaught for his interest in and contribution to the success of the meeting; and a vote of thanks was tendered the State University for the courtesies received at their hands.

The officers for the ensuing year are as follows:

President—C. C. Morris, Ohio State University, Columbus, O.
Vice-President—S. J. Mauchly, Woodward High School, Cincinnati, O.

Secretary-Treasurer—E. W. E. Schear, Otterbein University, Westerville, O.

Assistant Secretary—Margaret L. De Vereaux, High School, Alliance, O.

Much credit is due Prof. S. E. Rasor of Ohio State University for the successful and happy way in which all the arrangements for the meeting were perfected. On account of the flooded conditions prevalent throughout the state in the spring of 1913, this was the first meeting of the association since April, 1912. In spite of this long interval between the sessions there seemed no lack of enthusiasm. Rather, there was manifest a feeling that the association could be and should be a great stimulus to the mathematics and science teachers of the state.

HARRIET E. GLAZIER, *Secretary.*

SCIENCE QUESTIONS.

BY FRANKLIN T. JONES,

University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE AND MATHEMATICS *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

157. *Proposed by S. W. Hackett, Winthrop Normal and Industrial College, Rock Hill, S. C.*

Given a eudiometer tube of d mm. inside diameter, graduated in cubic centimeters, and A cc. of gas in top of tube, over mercury, the barometer reading being B mm. Required the reading on the eudiometer tube (in cc.) necessary to furnish an additional volume of gas of twice (or one-half) the mass of the original gas.

158. *Proposed by E. V. Hjort, Mason City, Iowa.*

Why can glass be cut under water with a pair of shears?

159. *Proposed by George Y. Sosnow, Newark, N. J.*

What would happen if 1000 calories of heat were applied to 80 gm. of ice at 0°C.?

160. *Proposed by H. C. McMillin, Washington, Kans.*

Compare the times of descent of a hollow and a solid sphere rolling down an inclined plane.

Solutions and Answers.

128, 130. *Also solved by P. K. Shah, B. A. (Bombay) and C. M. Jhaveri, B. A. (Bombay), Boys' High School, Sojitra, Baroda State, Bombay, Presidency, India.*

135, 136. *Also solved by S. Birnbaum.*

137. *Proposed by Theodore Cohen, Commercial High School, Brooklyn, New York.*

Manganese dioxide is allowed to react with a solution of hydrochloric acid. How would you teach this to a class as an oxidation-reduction reaction in electrical terms?

Notes by the Editor.

The explanation of oxidation-reduction reactions in electrical terms is

of doubtful usefulness in elementary classes in chemistry. Most classes in college have great difficulty in gaining any benefit from such discussions.

Oxidation and reduction from the electrical point of view are ably discussed in his books on analytical chemistry by Dr. Julius Stieglitz of the University of Chicago. Böttger's *Qualitative Analysis* also gives very satisfactory discussions of the same subject. From the point of view of the beginning student the explanations given by McFarland on pages 108-121 of his *Elementary Principles of Chemistry* are the best with which the Editor is familiar.

Solved by S. Birnbaum, Manual Tr. H. S., Brooklyn, N. Y.

138. *Proposed by Lewis H. Fee, Everett, Wash.*

Assuming that a 32 c. p. carbon filament lamp takes 1 ampere at 110 volts and that a 40 watt Mazda will give the same candlepower at the same voltage, how long will it take the Mazda lamp to pay for itself (cost 55¢) if it is operated 4 hours per day? Cost of electricity 12¢ per kw. hour.

Solution by C. E. Patton, Meeker, Colo.

$110 \times 1 = 110$ watts = power required for carbon lamp.

40 watts = power required for Mazda lamp.

12¢ per kw. hour = .012¢ per watt hour.

$110 \times 4 \times .012¢ = 5.28¢$ cost per night of c. f. lamp.

$40 \times 4 \times .012¢ = 1.92¢$ cost per night of Mazda lamp.

$5.28¢ - 1.92¢ = 3.36¢$ amount saved by Mazda each night.

$55¢ \div 3.36¢ = 16.37$ nights = 65.48 hours time required for saving cost of Mazda lamp.

Also solved by W. A. Tippie, Troy, Ohio, S. Birnbaum, Brooklyn, N. Y.

139. *Proposed by John Metschl, Milwaukee, Wis.*

Supposing that a hole were bored completely through the center of the earth and that a stone be dropped into the hole—(a) Would the stone fall completely through the earth or only to the center? (b) Would the stone describe simple harmonic motion in the hole? (c) Would the stone have any kinetic energy the instant that it reached the center of the earth? Give reasons for each answer.

Solution by S. Birnbaum, Man. Tr. H. S., Brooklyn, N. Y.

(a). The stone would perform a simple harmonic motion (since the force is proportional to the displacement).

(b). It would therefore go completely through the earth and oscillate up and back.

(c). The kinetic energy at the center of the earth would be

$$F \times 4000 \text{ miles}$$

where F is the average force acting on the body. But that is evidently one-half of the weight of the stone on the surface of the earth (since the force acting on the body at the center of the earth is zero).

Hence

$$\tfrac{1}{2} W + 4000 \text{ lbs. miles} = \text{kinetic energy at center}$$

where W is the weight in lbs.

141. *Proposed by G. Y. Sosnow, Newark, N. J.*

How much steam at 100° C. must be mixed with 1272 gm. of ice at 0° C., so that after the changes of state the result may be water at 0° C.?

Solution by C. E. Patton, Meeker, Colo.

Principle: Heat lost by steam equals heat gained by ice.

Heat of vaporization of water, 536 calories.

Heat of fusion of ice, 80 calories.

Let n represent number of grams of steam required.

Then $536n+100n = 1272\times80.$

$636n = 101760.$

$n = 160$ grams.

Also solved by W. C. Phebus, Lorain, Ohio, and H. C. McMillin, Washington, Kans.

142. *Proposed by Harvey Roeser, Stillwater, Okla.*

A person standing directly in front of the vertical middle line of a square post throws a slip noose over it and draws the line taut. It is a fact that the rope can not be drawn up to fit the post snugly. What will be the angle between the rope and the post?

Solution by H. C. McMillin, Washington, Kansas.

Denote tension in rope by T and angle between rope and post by α. One of equations of equilibrium is

$$T\sin\alpha+T\sin\alpha = T.$$

$$\sin\alpha = \tfrac{1}{2}.$$

$$\alpha = 30°.$$

Solution also proposed by W. C. Phebus, Lorain, Ohio, answer 30°.

THE STORY OF EXOGYRA—AN EXTINCT OYSTER-LIKE MOLLUSK WHICH ENABLES GEOLOGISTS TO IDENTIFY ROCK FORMATIONS.

Many thousands of years ago, before the birth of the Rocky Mountains and when the shores of the Atlantic Ocean and the Gulf of Mexico lay far inland from their present position—when, indeed, the North American continent was relatively very small—there lived in the seas and estuaries, together with various species of oysters, vast numbers of a closely related mollusk with a twisted shell which is now known to science as Exogyra. As the years passed, the colonies of Exogyra flourished, and the places of those that died were taken by younger members, while the old shells became entombed within the slowly accumulating deposits of sand, mud, and limy ooze. In the progress of the centuries there developed in the shape and ornamentation of the shells certain changes that were sufficiently pronounced to enable the specialist of today not only to distinguish the shells of members of the original colonies from those of their descendants but also to recognize several distinct varieties among the later shells.

In the course of time—a very long time, for we are speaking geologically—the stresses which had accumulated within the earth during an extended period of quiescence found relief in movements of the outer crust which brought about the uplift of the Rocky Mountains and materially altered the shape and size of the ocean basins. The resultant shifting of the ocean currents produced changes in the temperature of the water and in the abundance and character of the food supply. The unfortunate Exogyra, unlike his more hardy cousin, the oyster, was unable to adapt himself to the changing physical conditions and became extinct.

After the lapse of ages the retreat of the seas from the borders of the continent brought above sea level the sediments, now turned to stone and covered by a mass of later deposits, which contained the fossil shells of the Exogyra. Subsequent erosion by rain and running water has carved valleys and ravines which expose, from top to bottom, the fossiliferous sedi-

ments and enable the geologist to interpret their history, using the different varieties or species of Exogyra to identify definite rock beds and thus trace them across country with a certainty impossible without the aid of this prehistoric mollusk. The study of the many fossil animals, shellfish, and plants is of the greatest use in enabling the geologist to classify rocks which may contain important economic minerals.

MATHEMATICS NOTICE.

Teachers of mathematics who are interested in the wide scope of the applications of mathematics will find it interesting to read a paper by Professor I. J. Schwatt of the University of Pennsylvania, entitled "The Applications of the Calculus to the Medical Sciences," published in the American Journal of the Medical Sciences, March, 1914, page 409. Since this journal does not usually contain material of a mathematical nature, a special mention here seems desirable.

BOOKS RECEIVED.

High School and College Text-books, Descriptive Catalogue with Price List and Newest Books. Pages lxxii+533. 13x19 cm. Cloth. 1914. American Book Company, New York and Chicago.

Technical Trigonometry, by Horace W. Marsh, Pratt Institute. Pages x+232. 13x24 cm. Cloth. 1914. $1.50. John Wiley & Sons, New York.

Experimental Electrical Testing Monograph B-4, by Science Teachers. 78 pages. 14.5x22.5 cm. Paper. 1914. Weston Electrical Instrument Company, Newark, N. J.

Vom Tierleben in den Tropen, von Dr. Konrad Guenther, Freiburg. 41 pages. 13.5x20 cm. Paper. 1914.

Grundlehren der Themie, und wege zur künstlichen herstellung, von Naturstoffen von Dr. Ernst Rüst, Zurich.

Druck und Verlag von B. G. Teubner, Leipzig und Berlin.

The Elementary Principles of General Biology, by James Francis Abbot. Pages xvi+329. 13x19 cm. 1914. $1.50. The Macmillan Company, New York.

The Fungi Which Cause Plant Disease, by F. L. Stevens. Pages viii+754. 15x22.5 cm. 1913. $4.00. The Macmillan Company, New York.

The Stock Exchange from Within, by W. C. Van Antwerp. Pages v+459. 12.5x19. Cloth. 1914. Doubleday, Page and Company, New York.

Laboratory Guide to the Study of Qualitative Analysis, by E. H. S. Bailey and Hamilton P. Cady, University of Kansas. Pages x+280. 14.5x21 cm. Cloth. 1914. $1.25. P. Blakiston's Son & Company, Philadelphia.

Commercial Education in Germany, by F. E. Farrington. Pages viii+258. 15x19 cm. Cloth. 1914. $1.10. The Macmillan Company, New York.

Memorabilia Mathematics, by R. E. Moritz. Pages vii+410. 18x23 cm. 1914. Cloth. $3.00. The Macmillan Company, New York.

Rocky Mountain Flowers, an illustrated guide for plant lovers and plant users, with 25 plates in color, 22 plates in black and white, by F. E. Clements and Edith S. Clements, University of Minnesota. Pages v+392. 1914. Cloth. 17.5x25 cm. H. W. Wilson Company, White Plains, N. Y.

Business English, a practical book, by Rose Buhlig. Pages iv+381. 12.5x18.5 cm. Cloth. 1914. D. C. Heath & Company, Boston.

The Parents' Guide in Sex Problems from 5 to 75, by B. J. Kendall, M. D. 283 pages. 11.5x17 cm. Cloth. 1914. $1.00.

The Secrets of Success for Boys and Young Men, by J. B. Kendall. 11.5x17 cm. Cloth. 1914. 50 cents. J. B. Kendall, Geneva, Ill.

Technical Trigonometry by Horace W. Marsh, Pratt Institute, Brooklyn. Pages x+232. 13x21 cm. Cloth. 1914. $1.50. John Wiley & Sons, New York.

The Carnegie Foundation for the Advancement of Teaching. Eighth Annual Report of the President and Treasurer. Pages vi+158. 19x25 cm. Paper. 1913. 576 Fifth Ave., New York City.

BOOK REVIEWS.

The Principles of Physics, by Willis E. Tower, Englewood High School, Chicago; Charles H. Smith, Hyde Park High School, Chicago, and Charles M. Turton, Bowen High School, Chicago. Pages vi+462. 425 drawings and illustrations. 13.5x19 cm. Cloth. 1914. $1.25. P. Blakiston's Son & Co., 1012 Walnut Street, Philadelphia, Penn.

The authors of this text-book evidently believe that a working knowledge of the principles of physics can best be acquired by connecting up every principle studied with as many practical applications as it is possible to study in the allotted time. No other text in physics now in the field comes near being the equal of this in fullness of treatment of practical applications.

The principles are stated with the utmost simplicity and clearness and these statements of principles are followed by full discussions which make clear the formulae that are to be used in solving the problems.

The problems involve as a rule only the units employed in everyday measurements. Absolute units are explained but not emphasized, the emphasis being on the practical units.

A statement of important topics at the end of each chapter enables the pupil to study each chapter in its true perspective.

The illustrations are good. Most of them are new. A sectional view of a cream separator illustrates centrifugal force. The transmission gear of an automobile and the reducing gear of a steam turbine illustrate the use of gearing in reducing speed and of bevel gear in changing direction of rotation. The wall of a refrigerator and a thermos bottle illustrate non-conductors of heat. The thermostat illustrates expansion of metals by increase of temperature. The balloon, parachute, air brake, gas meter, and vacuum cleaner are used in illustrating mechanics of gases. These are only a few examples of the abundant practical illustrations.

The up-to-date-ness of the book is shown in the discussions of electric waves, radio-activity, and the Brownian movements.

We predict a successful future for this book as one of the leading text-books in physics. E. E. BURNS.

Plane Trigonometry and Applications, by E. J. Wilczynski, Ph. D., the University of Chicago. Edited by H. E. Slaught, Ph. D. Pages xi+265. 15x21 cm. 1914. Allyn & Bacon, Boston.

The usual subject matter of a course in trigonometry is here presented in rather unusual and inviting ways, so that the book deserves recognition and will, no doubt, have a wide use.

Since the method of presentation is heuristic from beginning to end, the student is able to comprehend the subject through his own efforts,

and is able to recognize and grasp the fundamental ideas. The book is divided into two parts; the first part is devoted to the theoretical and numerical solution of triangles, and the second part treats of the functions of the general angle, their addition theorems and other properties, and applications to simple harmonic curves, simple harmonic and wave motion, and harmonic analysis. The whole theory of triangle has been unified by giving the area problem the central position.

In connection with the discussion of topics considerable historical matter has been introduced. The applications cover a wide field and are introduced in a systematic manner. The slide rule is briefly explained, short methods of computation are given, common sources of error and the methods of detecting and correcting errors are discussed. H. E. C.

Alle Jahreskalender auf einem Blatt, by Dr. Doliarius (Joh. Ed. Böttcher), Leipzig. 9x15 cm. 30 Pf. B. G. Teubner, Leipzig, Germany.

This ingenious little perpetual calendar of pocket size is arranged so that one can use it without making any calculations or remembering any date or formula. When it is set for any date the calendar for the whole year is visible. H. E. C.

Darstellende Geometrie des Geländes, by Dr. Phil., Rudolf Rothe, Professor an der Technischen Hochschule, Hannover, Germany. Pages 67. 12x18 cm. Price M.—.80. 1914. B. G. Teubner.

Volume XIV of the Mathematische Bibliothek, edited by Dr. W. Lietzmann and Dr. A. Witting gives many applications of geometry in simple problems of topographic surveying including the plotting of profiles and the construction of contour and relief maps. The discussion of these problems is more easily grasped because of the large number of figures and diagrams, eighty-two in all. The book should prove of practical value to classes in descriptive geometry and in surveying. H. E. C.

Elementary Theory of Equations, by Leonard E. Dickson, Ph. D., Professor of Mathematics in the University of Chicago. Pages v+184. 16x23 cm. $1.75. 1914. John Wiley & Sons, New York.

The number of American text-books in the elementary theory of equations is not large and the present volume meets a distinct need. Especial care has been taken in stating theorems accurately and giving correct proofs. The plan of leading up to the general theorems by concrete illustrations and special cases lightens the task of the average student in this subject.

In each chapter there appears to be some topic or method of presentation that strikes one as decidedly interesting: Chapter I. The Graph of an Equation; Caution in Plotting; Bend Points; Derivatives; Chapter II. Complex Numbers; De Moivre's Theorem; Roots of Unity; Chapter III. Algebraic and Trigonometric Solution of Cubic Equations; Algebraic Discussion of Irreducible Case; Chapter IV. Algebraic Solution of Quartic Equations; Methods of Ferrari and Descartes; Chapter V. The Fundamental Theorem of Algebra; Graphical Discussion; Chapter VI. Elementary Theorems on the Roots of an Equation; The Term, "Divisor"; Newton's Method; Chapter VII. Symmetric Functions; Waring's Formula; Chapter VIII. Reciprocal Equations; Construction of Regular Polygons; Trisection of An Angle; The Solution of $x^n = 1$ by Square Roots; Duplication of Cube; Chapter IX. Isolation of the Real Roots of an Equation with Real Coefficients; Rolle's Theorem; Simplification of Sturm's Theorem; Budan's Theorem; Fourier's Method; Chapter X. Solution of Numerical Equations; Graphical Discussion; Newton's Method; Gräffe's Method; Chapter XI. Determinants; Chapter XII. Resultants and Discriminants.

The book contains about 500 exercises. It seems the irony of fate that after the careful reading of the proofs noted in the closing paragraph of the preface there should be a misstatement in the first paragraph. H. E. C.

A History of Japanese Mathematics, by David Eugene Smith and Yoshio Mikami. Pages 288. 15x24 cm. $3.00. 1914. The Open Court Publishing Company, Chicago.

Gow's *History of Greek Mathematics* and Ball's or Cajori's *History of Mathematics* have been a never failing source of inspiration for many teachers. The story of Japanese mathematics as told by Smith and Yoshio has the like charm of early gropings toward a number system and methods of calculation, and the development of algebra, geometry and calculus, at first influenced little or not at all by the work of other nations and finally losing its identity as the learning of other nations molds it into the universal form.

The large number of photographic reproductions and drawings from texts and manuscripts present, vividly, the many peculiarities of material and form of early Japanese mathematics. This volume should be in every high school library. It deals largely with the problems of elementary mathematics. H. E. C.

Industrial and Commercial Geography, by J. Russell Smith. 1913. 33 chapters, 914 pages, 244 figures, maps and illustrations. A good index and fair bibliography. $3.50. Henry Holt & Co.

This is an authoritative and a much needed text which forms an excellent conspectus of the world. It aims "to interpret the earth in terms of its usefulness to man." The subject matter consists of two parts, the first of which deals with the industries and the second discusses the commercial aspects of trade routes of the different countries, their development and their comparative values. In Part I, the fundamental agricultural industries are accorded a rational treatment. These discussions of lands, agriculture, the cereals, animals, fruits, etc., are geographic in that they are human action dependent upon geographic factors. This section gives the manufacturing industries, a vast geographic aspect which is far superior to any previous texts. The use of status is not over emphasized but ample to prove the principles. Part II comprehends the trade and commerce phase of world geography. The factors of trade and the development of trade centers are well developed in their relative geographic influences. The treatment of the trade routes of North America is a type of the eight different regions discussed. The special value of these discussions is that each of the principles is clinched by the different details which are clearly and pointedly stated. The text is free from the vast cloud of unnecessary details which is so conspicuous in some of the older commercial geographies. W. M. G.

Geography and Industries of Wisconsin, by R. H. Whitbeck, Geological Survey of Wisconsin. Educational series No. 3. Bull. No. 26, 1913. Six chapters, 48 figures, 90 pages and 20 plates.

The various state geological surveys are supplying in their educational bulletins some excellent material for the study of state geography. This bulletin by Professor Whitbeck of the University of Wisconsin is an excellent exposition of the state's resources and industries from a geographical standpoint. The underlying causes of the industrial growth of a region are very definitely stated and the principles applied to the state. The wood products, butter and cheese, iron and steel, tanning of leather and brewing of malt liquors are Wisconsin's chief industries. The milk products of the state equal the entire gold production of the United States and yet the state growth of the state is comparatively recent. An excellent

page plate in color shows the distribution of its creameries, cheese factories and condenseries which number over three thousand. The state's greatest geographical asset is its waterfront along Lake Michigan. This bulletin combined with the large map issued by the state survey ought to be widely used by the teachers of Wisconsin and in the library of those studying the industrious factors in modern geography. W. M. G.

The Teaching of Geography in Elementary Schools, by R. E. Dodge and C. B. Kirchway. 1913. 16 chapters, 244 pages, appendix and index. Rand McNally & Co.

A compact, comprehensive discussion of the educational problems involved in the teaching of geography. The book is successful in its determination of good geography for the grades, its solution of some of the special teaching problems and its application of the educational principles. The chapters on the "Course of Study," "Principles of Geoggraphy," "Industrial and Commercial Geography," "Geography in the Upper Grades" and "Home Geography" are of special value in dealing directly with the frequent problems of the teacher. Emphasis is given actual study of modern geography in the preparation of teachers. This preparation should be largely in the field of regional geography.

The book is well provided with some lists of maps, text-books, supplementary reading, instruments, pictures and lantern slides. The sane ideas advocated by these authors will be of much influence in the teaching of modern geography. W. M. G.

The Oxford Industrial Readers, by A. O. Cooke. 1913. Published by Oxford University Press, American Agents, Doran & Co., N. Y.

These books are not geographical, yet they contain such excellent material relative to the great industries that they are mentioned here. Each book has about 85 pages, 4 colored plates, 18 figures, 6 plates and 11 chapters. They sell for about 35 cents each. The material consists of carefully written and clear description of the stages in the manufacture of the various articles. For subject matter, for industrial schools, these books are the best published. The volumes so far issued are: *A Day in a Shipyard, A Visit to a Woolen Mill, A Day with Leather Workers,* and *A Visit to a Cotton Mill.* The facts are clearly stated, the figures are well drawn, the printing and paper are excellent. W. M. G.

Experimental Mensuration, by H. Stanley Redgrove, Assistant Lecturer in Mathematics at the Polytechnic, London, W., and Mathematical Master at the Upper Tooting High Schools. Pages xvii+328. 13x19 cm. Price $1.25. 1913. D. Van Nostrand Company, New York.

In a preface of nearly six pages the author presents a vigorous and effective discussion of the teaching of geometry. The whole is worth reproducing but there is space for only a single paragraph. "The ancient world had no experimental science, therefore, in learning geometry the student must proceed only by deduction from certain assumptions; in spite of the facts that deductive reasoning is not the method of discovery and the purely deductive method is wholly unsuited to the youthful mind. Euclid knew practically no arithmetic; therefore, in learning geometry the student must proceed as though he too knew no arithmetic, though quite capable of dealing with arithmetical problems that Euclid would probably have been unable to solve. The absurdity is apparent. One can only echo the words of Professor Perry: 'Surely it is an abominable thing to maintain the present artificial distinction between geometry and mensuration when they are both really the same, and to scorn arithmetic, which we now know, because Euclid, being ignorant, did not use it.'"

This elementary text-book of inductive geometry is intended for beginners and leads the pupil, as far as possible, to discover everything for

himself by means of experiments. Conclusions are drawn from the experiments and the pupil is shown how his conclusions can be deduced from the results of his previous experiments. All the details of this method of teaching geometry seem to be worked out and applied carefully, and there is a logical sequence and coherence which should give sufficient training in clear thinking. There is a large amount of arithmetical computation throughout the book as well as exercises in drawing and construction. Considerable use is made of the angle functions in finding areas and solving practical problems. The drawings and diagrams are good and will prove helpful to the pupil. Teachers of geometry should include this text among their reference books, and let it influence their teaching of geometry. H. E. C.

Representative Cities of the United States, by Caroline W. Hotchkiss. 1913. 13 chapters, 19 maps, 79 illustrations, and 212 pages. Good index and an appendix of geographical facts. 60 cents. Houghton, Mifflin & Co.

This book selects thirteen type cities of the United States and imparts new interest by the clear and attractive presentation of its modern geographical material. The three cities selected on the Pacific coast are San Francisco, Portland and Seattle. The discussions show the author's ability to arrange material to interest children in the rational phase of geography. Pittsburgh, Gary, Boston, Chicago and New York are among the other cities. In Pittsburgh and Gary the emphasis is upon the iron and steel industry, Boston, its historical relations, Chicago, its importance as an inland center of trade and industry, and New York as the city of amazing growth and foreign trade.

At the end of each chapter is a set of suggestions and questions which are very effective in giving direction to the pupil's study. The book will be a necessary tool in the hands of the teacher who is giving a course in the geography of the United States. W. M. G.

High School and College Text-Books, Descriptive Catalogue and Price List and Newest Books. Pages lxxii+533. 13x19 cm. Cloth. 1914. American Book Co., New York.

This volume represents the very highest cut in book catalogue making. It is a real book, containing a brief description of all the publications by this firm. There is a splendid table of contents, followed by a complete price list, index and code word of all the books described in the volume. A very full outline of new and forthcoming books is published. In the body of the book there is a short description of each text made by this firm, similar to that at the beginning of this review. This is followed by a comprehensive review, in almost every case, of the books manufactured by this house. Many testimonies from users of these books accompany the review.

Teachers should put a copy of this catalogue into their library in order to know what is being done in the world of new school text-books. C. H. S.

Veränderliche und Funktion, by Moritz Pasch. Pages vi+186. 1914. Price M. 7.—B. G. Teubner, Leipzig.

The author of the present work is very well known even among those who confine their attention to elementary mathematics. His *Vorlesungen über Neuere Geometrie*, Leipzig, 1882, constitute the beginning of the modern movement towards a careful study of the foundations of elementary geometry. Among the other leaders in this field we may mention the following: Veronese, Peano, and Hilbert. Some of the results of this movement have been clearly exhibited in the monograph entitled "The

Foundations of Geometry" by Ostwald Veblen, published in the *Monographs on Topics of Modern Mathematics*, edited by J. W. A. Young; and also in the *Rational Geometry*, by G. B. Halsted.

In 1909 M. Pasch published a work entitled *Grundlagen der Analysis*. The present volume constitutes a continuation of this work and deals with various questions relating to fundamental concepts of mathematics. Comparatively little space is devoted to the concepts of variable and function, which are named in the title of the book, but the other concepts considered are closely related to these fundamental ones. In view of the fact that these concepts lie at the base of mathematics, the book can be read with profit even by those who are restricting themselves to the elements of mathematics. The treatment is, however, quite abstract and calls for considerable maturity in mathematical thinking. G. A. MILLER.

Qualitative Chemical Analysis, a laboratory text treating of the common elements and their compounds, by Anton Vorisek, Professor of Analytical Chemistry, College of Pharmacy, Columbia University, in the City of New York, with a plate of spectra, tables and three text figures. 16x24x1.5 cm. $2.00 net. P. Blakiston's Son & Co., Philadelphia.

A fresh and modern method of treatment characterizes this new qualitative analysis text. A number of excellent innovations as to method of presentation and some new methods of detection have been introduced.

The compactness of the material will commend the text to those who lack time for a more exhaustive course. An excellent descriptive list of chemicals and reagents appears in the index. The last twenty-five pages contain a very good condensed elementary account of the theory of solutions as applied to reactions in solution. F. B. W.

School Algebra, by Fletcher Durell, Ph. D., Head of the Department of Mathematics in the Lawrenceville School. Pages 507+lxviii. 13x19 cm. 1911. Charles E. Merrill Company, New York.

The author states that this book was written with the purpose of simplifying principles and giving them interest, by showing more plainly, if possible, than has been done heretofore, the practical or common-sense reason for each step or process. It is shown that new symbols are used in algebra to represent numbers for the purpose of shortening work and gaining power.

Among the features of this algebra may be noted the following:

The large number of written problems throughout, and those in the first part of the work grouped in types. Thus, problems of Type I are of the form $x+ax = b$, of Type II $x+x+a = b$, of Type III $x+ax+b = c$, and so on.

Many informational facts are used in the written problems; and nine pages of numerical data from the fields of arithmetic, geometry, physics, engineering, history, and so on, are given to be used by the teacher or pupils in making new problems.

The principles of arithmetic are reviewed by means of examples, and numerous reviews of the part of algebra already studied are secured by lists of problems.

Utilities in algebra are discussed and emphasized by special exercises. A brief history of algebra is given in a chapter of twelve pages, and the attention of the pupils in recalled to this important subject from time to time by questions placed in various parts of the book.

From the unusually large number of problems and exercises, teachers can make selections in accordance with the needs of various localities.

H. E. C.

"Industrial Organic Analysis" for the use of technical and analytical chemists and students, by Paul S. Arup, B. S. A. C. G. I. 13.5x19x2 cm. Pages xii+240. 1913. $2.25, net. P. Blakiston's Son & Co., Philadelphia.

This work is frankly for advanced students of chemistry and for reference use by industrial chemists. It attempts to provide material by the use of which the student who has been well grounded in the fundamentals of pure chemistry may make himself of more immediate use in the industry to which he will subsequently devote his attention.

Since too early specialization is inadvisable, the author has selected only subjects of more general interest and methods which have general application.

The chapters are but eight in number, the author preferring to handle a small number of subjects well rather than a larger number superficially. The subjects chosen are: 1, Coal and Coke; 2, Coal Tar and Its Distillation Products; 3, The Fatty Oils and Fats; 4, Soap; 5, Petroleum and Its Distillation Products; Lubricating Oils; 6, Milk and Butter; 7, Starch and Its Decomposition Products: Flour, Barley and Malt, and, 8, Preservatives and Artificial Coloring Matters in Foods.

The treatment throughout is thoroughgoing, the principles employed being usually advanced briefly then followed by the practice. F. B. W.

Elementary Chemistry, by Alexander Smith, Professor of Chemistry and Head of the Department of Chemistry in Columbia University. 15.x19x2.5 cm. Pages viii+439. 1914. List price, $1.25. The Century Company, New York.

A new high school text in chemistry and apparently a very good one in many respects. While not yielding unwisely to the popular clamor for applied chemistry, the author has nevertheless related the chemistry to the affairs of daily life.

The fundamental principles have justly received the most attention, the descriptive and applied chemistry being used to illustrate the principles.

The order of topics shows some originality in parts, in other parts, especially in the treatment of the metals in the latter part of the book, the order is less original.

The air is studied before oxygen, but hydrogen before water, thus changing from what might be called a natural order to what would be called a systematic order. The reviewer would prefer to stick to the natural order in this case and come upon hydrogen while studying the familiar substance, water, and then study hydrogen.

The difficult subject of formulae and equations is attacked rather early in the text (page 59) but the author advises omitting this chapter if deeemed wise.

The questions at the ends of the chapters are of a type tending to cause thought.

The book is virtually in two parts with a review at the end of Chapter XXX and with another at the end of the last chapter (Chapter XLII). There is in addition to these reviews a consistent effort evident to correlate the various parts of the work and to bring up in new ways and thus effectively to review what has gone before.

This text should have a considerable sale and especially among those who appreciate real science work as distinguished from mere "busy work."

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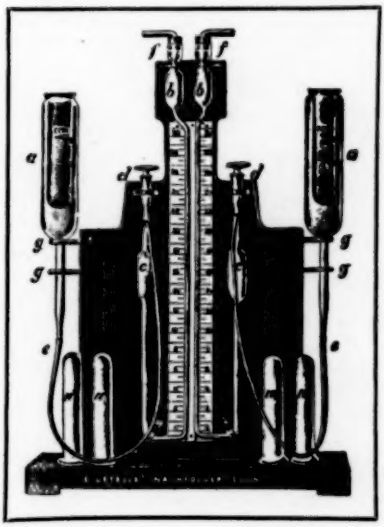

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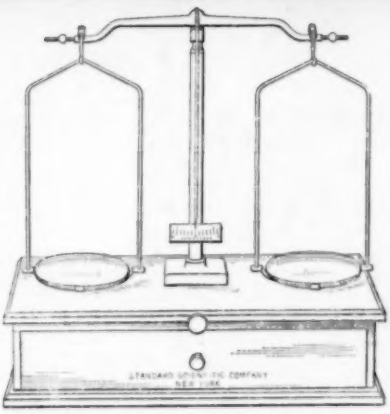

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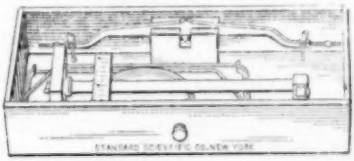

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